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NAVPERS 93020

GUNNER'S MATES SCHOOL CLASS "A"

TRAINEE'S GUIDE

JANUARY 1964

VOLUME I

BUREAU OF NAVAL PERSONNEL

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TRAINEE'S GUIDE
GUNNER'S MATES SCHOOL CLASS "A" COURSE, NAVPERS 93020

1. This publication has been prepared for use as a text in the Gunner's Mates School Class "A" course. The Instructor's Guide, NavPers 93019, has been prepared as a companion publication.

2. Corrections and recommended changes to this publication are invited. Commanding Officer, Service School Command, Great Lakes, Illinois, is hereby assigned clearing house responsibility for evaluating and compiling recommended improvements and for submitting them to the Chief of Naval Personnel in the form of a change to the publication. Activities using this course material are requested to submit their recommended changes directly to the Commanding Officer, Service School Command, Great Lakes, Illinois, with a copy to the Chief of Naval Personnel (Attn: Pers-C1).

3. This publication supersedes the preliminary edition of NavPers 93020.

MDGastrock

M. D. GASTROCK
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SAFETY NOTICE

General:

To avoid casualties, the observance of the following safety rules is mandatory. The Bureau of Naval Weapons shall be informed of any circumstances that conflict with these safety precautions or of safety precautions which for any reason require changes or additions.

When the exact meaning of a safety precaution is doubtful, an interpretation shall be requested from the Bureau of Naval Weapons. If conditions not covered by these safety precautions should arise which, in the opinion of the commanding officer, could render further operation of the equipment unsafe, none of the existing safety precautions shall be interpreted as authority for performance of further operations.

Since familiarity with any equipment, no matter how dangerous it may be, is apt to lead to carelessness, all persons who supervise or perform work on weapons or weapon systems shall exercise the utmost care that all regulations and instructions be rigidly observed and shall constantly supervise the personnel working under their supervision, reminding them frequently of the necessity of observing the safety rules in the performance of their work. NO RELAXATION OF VIGILANCE SHALL EVER BE PERMITTED.

To prevent possibility of accidents, the safety devices provided shall always be used as designated and shall be kept in proper operating condition. All instructions promulgated by competent authority regarding the use of these devices shall be strictly observed.

Changes and modifications of or additions to ordnance equipment shall not be made without explicit authority from the Bureau concerned.

Moving Equipment:

All personnel whose duties involve the operation of moving ordnance equipment shall be thoroughly familiar with the safety precautions applicable to and the operational instructions for that equipment.

Except at general quarters, a safety watch shall be posted on all power equipment that is capable of inflicting injury to personnel or material and is not continuously visible to the controlling station. The safety watch and controlling station shall have telephone or other effective voice communications established before any operation of the equipment is attempted.

All personnel taking part in or observing the operation of power equipment shall remain alert and keep clear of moving parts. At no time will skylarking be allowed in the vicinity of operating power equipment.

Electrical:

A large number of electrical casualties are due mainly to sheer carelessness; therefore it is important that all personnel be warned of the dangers of electrical shock. All persons authorized to repair or maintain electrical equipment must be constantly aware of the urgent need to be alert and must be cautious in carrying out their duties.

Since weapon systems employ voltages up to 440 volts which are extremely dangerous, only authorized personnel who have been duly assigned for system upkeep shall work on this equipment.

Whenever possible, the main supply and power switches shall be turned off and tagged before checking or overhauling an electrical circuit. When electrical equipment has to be serviced or adjusted with the power covers removed and the circuits energized, the following safety rules shall be observed:

1. Always work in the presence or with the assistance of another person who is capable of rendering first aid.

2. Remove rings, wrist watches, bracelets, and other metal items.

3. Do not change fuses or lamps in power panels when the electrical circuits are energized.

4. When making adjustments, use only tools with adequately insulated handles.

5. Keep hands, clothes, and shoes dry.

6. Ensure good insulation from ground with some suitable nonconducting material, such as dry wood, several layers of dry canvas, or rubber mats of approved construction.

Under certain conditions, dangerous voltage potentials may still exist in circuits even after the circuits have been deenergized, due to the capacitors which retain their charge. These circuits can be discharged by grounding them. Remember: ALWAYS CHECK AN ELECTRICAL CIRCUIT WITH A VOLTMETER TO ENSURE THAT THE CIRCUIT IS OPEN.

Electrical safety precautions shall be posted on or near each group of electrical or electronic equipment. Specific safety precautions pertaining to electrical equipment are contained in U. S. Naval Safety Precaution, OPNAV 34P1 (1953) and in NavShips 250-000, Chapter 60.

A thorough knowledge of the currently prescribed methods for administering artificial respiration to victims of electrical shock is essential. NavMed P5056 describes the correct methods of resuscitation.

Explosive Ordnance:

Missiles, as well as gun ammunition, bombs, rockets, and torpedoes, are extremely dangerous; therefore constant vigilance and intelligent supervision must be exercised during handling and storage of missiles and missile components.

Missile boosters shall be handled with extreme care. A slight blow may crack the propellant grain and cause an explosion when the weapon is fired. Care shall be taken that no heat is applied to or near boosters.

Missile warheads are classified as bomb-type ammunition; therefore all general safety precautions for handling high-explosive and bomb-type ammunition shall be exercised when warheads are being handled. Since warheads become dangerous when their temperature reaches 170°F., they must not be unnecessarily exposed to direct sunlight.

Handling of missiles and missile components shall be kept at a minimum. Live missiles shall never be used to check out the equipment.

HOW TO USE YOUR TRAINEE'S GUIDE

Gunner's Mates School Class "A" Course, Trainee's Guide:

This Trainee's Guide has been prepared for your use during the course of instruction and your future duty assignments. It does not supersede any other publication.

Other Publications:

The reference publications pertaining to the individual topics are listed, under the appropriate subheading, on the first page of each topic. To derive maximum benefit from this course of instruction, conscientiously study all assignments.

Many topics also include an optional reading list. The reading of the material listed under this subheading is not compulsory, and the publications listed may not always be available for classroom use; the optional reading list is primarily included for reference you will need in the future.

Presentation of Course Material:

The course material has been divided into sections and topics in which the material is presented in logical sequence. The training goals and skills to be acquired are usually stated at the beginning of each topic and provide a means for checking your progress before you proceed to the study of the next topic.

At the end of each section there is a page to be used for classroom notes. The accuracy of your notes will be checked by the instructor after completion of each section.

Quiz Sheets:

Quiz sheets are included at the end of each section or in the reference material. The answers to the questions may be found in the corresponding section of the Trainee's Guide or in the applicable reference material. The quizzes are provided to enable you to check your own progress in studying the course material.

Written and Performance Tests:

Written and performance tests will be conducted throughout the course of instruction. The tests will be administered by the instructor for his evaluation of your progress.

Safety Precautions:

A safety notice has been included in the front matter of this Trainee's Guide. This notice contains general safety precautions and instructions applicable to personnel associated with weapon systems. Furthermore, specific safety precautions are included wherever required in the text. Read these instructions carefully and develop safe working habits that will ensure not only your own safety, but also the safety of all those working with you.

TRAINEE'S GUIDE
FOR
GUNNER'S MATES CLASS "A" COURSE

NAME ______________________________

SERIAL NO. ________________________

GM SCHOOL ________________________

CLASS NO. _________________________

RECORD OF CHANGES AND CORRECTIONS

Number or Description of Change	Made by	Date

Section 1

WEAPON SYSTEM ORIENTATION

ASSIGNMENT-DISCUSSION-QUIZ SHEETS

Topic No.	Topic Title	Page
1.	Introduction	2
2.	Weapon System Concept	4
3.	New Developments in Weapon Systems	8

TOPIC 1: INTRODUCTION

You Are Now Going To Learn:

1. The mission of the weapon systems.
2. Why you were selected for this course.
3. The duties of a gunner's mate.
4. The scope of the course.
5. Methods that will be used to evaluate progress of trainees.

Discussion Points For This Topic Are:

1. Introduction.
2. Qualifications.
3. Weapon systems.
4. The duties of a gunner's mate.
5. Scope of the course.
6. Evaluation of trainee's progress.
7. Review and summary.

INFORMATION AND DISCUSSION:

The Staff welcomes you to the Gunner's Mates School. We wish you success as you embark on the second phase of your Naval career.

The Navy is constantly improving its many training programs, in order to keep pace with modern technical advancements.

Your ability to adapt yourself to Navy life and to meet the Navy's high standards of performance is a credit in itself.

During the early days of your training, you learned that the mission of the Navy is to control the seas. To accomplish this mission, the Navy depends on her weapon systems and the gunner's mates who maintain and operate them.

It's true that all ratings in the Navy are important and that team work is essential. The gunner's mate, however, should have more pride than all others in his work, because all Navy ratings are auxiliary to the rating of gunner's mate.

The gunner's mate of today is expected to maintain and to operate the weapon systems which are results of America's most advanced scientific research and development and precision-products of American ingenuity and industry.

You were selected for training not by chance; your high standing in mathematics, your excellent ability to learn, and your other outstanding qualities earned you the privilege of attending this course. You will learn about basic machines, hydraulics, electricity, and electronics. This is the only course offered by the Navy where a man simultaneously studies so many technical subjects.

This course of instruction will be presented in the order listed in this Trainee's Guide, which you are going to have with you throughout the course.

Your progress will be evaluated by using written quizzes, written examinations, and by your performance. A Navy man's marks constitute a very important part of his service record; they are a decisive factor in determining his selection for advancement in rating, for future assignments to ships, and for the Navy's more advanced courses.

If you find that your knowledge of a particular subject is deficient, discuss the problem with your instructor. His background and experience will prove beneficial to you. Also, if you feel that you will benefit from additional study, do not be hesitant to request additional instructions.

Upon graduation from this course, you will be expected, with proper instructions from and under supervision of senior petty officers, to maintain and operate all weapon systems to which you are assigned.

The Staff of this school places its confidence in you and is ready to assist you with all your problems.

TOPIC 2: WEAPON SYSTEM CONCEPT

You Are Now Going To Learn:

1. Evolution of naval weapons.
2. Elements of a weapon system.
3. Requirements of weapon systems.

Discussion Points For This Topic Are:

1. Guns.
2. Gunpowder.
3. Fire control.
4. Weapons in general.
5. Elements of a weapon system.
6. Requirements of weapon system.
7. Review and summary.

INFORMATION AND DISCUSSION:

Near the middle of the thirteenth century, Friar Roger Bacon of England gave the Western World of that time the first effective formula for gunpowder.

Also in the thirteenth century, Friar Bertholdus, nicknamed 'The Black,'' of Freiburg, Germany, discovered the principles of the gun.

However, for a long time after the invention of the gun, people argued whether bows or guns were more efficient: A crossbow bolt could penetrate a knight's armor, but the bullet of an early gun could not; also, the archer with the long bow could shoot several times while the gunner was loading and firing a single round.

Until less than two hundred years ago, naval guns were still fired at point-blank range. Fire control was mainly a matter of skillful seamanship: The captain of the ship had to maneuver his vessel within shooting distance of the enemy to make a hit probable.

The major factor in the development of the science of gunnery is war, since every war necessitates not only the development of new weapons, but also the improvement and adaptation to new uses of already existing weapons.

The continuous improvements of gun propellants have greatly increased the lethal range of our present-day guns. However, the improvements of gun ranges can make the guns more effective only if the guns are adequately controlled.

The evolution of gun-fire control began in the nineteenth century with the invention of fixed sights and continued with the development of movable sights. The telescopic sight was introduced in the 1840's.

The most important fire control innovation was radar, which opened the door to new possibilities in naval warfare. Radar was also one of the main contributing factors to the enormous accent placed on electronics.

The following is a list containing brief descriptions of guns and other weapons used in the Navy:

Guns:

A typical gun consists of a tube, closed at one end, from which a projectile is fired by burning a propellant-charge in an enclosed space. Guns are general-purpose weapons used against surface ships, aircraft, shore installations, and enemy personnel.

Rockets:

Rockets are selfpropelled weapons and particularly suited for firing from small craft and airplanes because they have no recoil.

Guided Missiles:

Guided missiles are fairly new weapons. They can travel great distances with heavy loads, are selfpropelled, and contain their own guidance system.

Torpedoes:

Torpedoes are selfpropelled underwater missiles used against enemy ships.

Underwater Mines:

Underwater mines are weapons used to hinder enemy ship operations.

Depth Charges:

Depth charges are antisubmarine weapons which are exploded at a predetermined depth or at a certain distance from the submarine.

Bombs:

Bombs are all missiles dropped by aircraft, except guided missiles, torpedoes, and mines.

Chemicals:

Chemicals are toxic materials which can be fired in projectiles from guns or mortars or can be dropped by aircraft.

In today's warfare, the use of just one single kind of weapon cannot be considered effective. To achieve the desired results, a combination of various weapon-types and equipment is essential. To be effective, a weapon system must include the following:

1. Units for detecting, locating, and identifying the target.

2. Units for directing a delivery unit or weapon to the target.

3. Units for initiating delivery of or for delivering the destructive device of a weapon to the target.

4. Units for destroying the target when the target is approached or contacted.

An efficient naval weapon system must possess the following qualifications:

1. Reliability--The system must be capable of functioning continuously under adverse conditions for long periods at specified rates (certain number of rounds fired per minute, number of hits at specified accuracy, etc.).

2. Flexibility--The system must be capable of functioning satisfactorily regardless of the inadequacies of power supplies (such as power fluctuations), mismated parts, or design deficiency. The system may also be required to function satisfactorily with certain components omitted.

3. Safety--The system cannot be made absolutely foolproof; but, wherever possible, hazardous conditions must be eliminated by interlocks or other means, to avoid danger to friendly ships and aircraft or to own ship's structure or personnel.

4. Simplicity of Operation--Although basically all modern weapon systems are extremely complicated, they must be designed so that human beings are able to operate them with the minimum of difficulties. These facts are always considered in the design of control arrangement,and in the provision of safe and comfortable operating conditions for the personnel.

5. Maintenance Capability--The system must include long-life components to avoid constant testing, frequent repairs, and replacements of parts, especially where electronic components are involved.

TOPIC 3: NEW DEVELOPMENTS IN WEAPON SYSTEMS

You Are Now Going To Learn:

1. Elements of a missile system.
2. Characteristics of a basic missile system.
3. Requirements of a missile system.

Discussion Points For This Topic Are:

1. Definitions of missiles.
2. Missile guidance.
3. Launcher.
4. Feeder system.
5. Weapon control system.
6. Handling of weapons.
7. Requirements of a guided missile system.
8. Review and summary.
9. Section review.
10. Written test.

INFORMATION AND DISCUSSION:

A missile is an object that can be projected or thrown at a target. A missile can be a stone or an arrow, as well as a gun projectile, bomb, torpedo, or rocket. The expression "missile" is gradually becoming synonymous with "guided missile". A guided missile is an unmanned vehicle that travels above the earth's surface. It carries an explosive warhead or any other destructive load. A guided missile is selfpropelled and capable of being guided or of controlling its own trajectory.

An intercept-aerial guided missile is a more effective device of defense against enemy aircraft than a gun projectile; a missile can intercept attacking aircraft at greater height and longer range than gun projectiles.

The missile guidance system keeps the missile on the proper course to intercept the target. The guidance information may be transmitted by radio or radar from the launching site, from other control points, or from the target itself.

There are several types of missile guidance, and certain missiles require more than one type of guidance. A guidance system picks up guidance information from a certain source, converts the information to a signal to activate control devices, which move the flight-control surfaces (wings or fins) of the missile.

A guided missile launching system is basically composed of the following three major components:

1. Launcher.

2. Feeder system.

3. Weapon control system.

The purpose of a launcher is to support the missile during the last handling stages prior to firing.

The feeder system automatically delivers the weapon (missile/booster combination), in condition for firing, from the ready-service magazine to the power-driven, remotely controlled launcher.

The weapon control system consists of the fire control equipment and weapon direction equipment.

NOTE: Although a gunner's mate will not be required to maintain or operate other equipment than the launcher and feeder systems, he must have some knowledge of the weapon control system in order to participate in teamwork on these missile systems with personnel of other ratings.

The weapon control system on a DLG-class ship performs the following functions:

1. Designates specific weapons for engagement with specific targets.
2. Assigns specific directors to specific targets.
3. Assigns the launcher to the appropriate missile fire-control radar.
4. Fires single missiles or salvos.
5. Maintains missile guidance.
6. Monitors missiles in flight.
7. Arms BTN-warheads at the appropriate time.
8. Detonates BTN-warheads at the appropriate time.
9. Determines the probable damage to the target.

All missile launching systems have missile handling and stowage equipment. Because of the heavy weights, missile handling requires use of power-driven equipment.

In the future, the Fleet will considerably increase the number of its missile launching systems. Therefore you should try every day to improve your performance, since you can look forward to a very interesting and rewarding career in this field.

NOTE: More details about missile systems are provided in Section 19.

NEW DEVELOPMENTS IN WEAPON SYSTEMS

QUIZ SHEET:

1. The range of modern guns was increased by the improvements of gun ______________.

2. The development of gun fire control began in the nineteenth century with the invention of

   ____

   and continued with the invention of movable sights.

3. The most important contribution to the improvement of fire control was the invention of _____ __________.

4. The first useful formula for gun powder was given to the world in the ____________ century.

5. What advantage do rockets have over guns?

   ____

6. A modern weapon system must have the following qualities:

   a. ____________________.
   b. ____________________.
   c. ____________________.
   d. ____________________.
   e. ____________________.

7. An effective naval weapon system must include units for detecting, locating, and ________ the target.

8. Missile control surfaces can be either wings or ________.

9. The three major components of a missile launching system are:

   a. ____________________.
   b. ____________________.
   c. ____________________.

10. The weapon control system monitors a missile in flight.

    True ______ or False ______.

Accuracy of notes checked by instructor:

Date ______________________________

Trainee's initials ___________________

Section 2

WEAPON SYSTEM FUNDAMENTALS

ASSIGNMENT-DISCUSSION-QUIZ SHEETS

Topic No.	Topic Title	Page
1.	Fundamental Concepts	16
2.	Identification and Care of Ordnance Equipment	36
3.	Documentation	44
4.	General Safety Precautions	50

TOPIC 1: FUNDAMENTAL CONCEPTS

You Are Now Going To Learn:

1. The basic terms applicable to a gunner's mate's rating.
2. The organization of a gunnery department.

Discussion Points For This Topic Are:

1. Ordnance and gunnery.
2. Ballistics.
3. Weapon systems.
4. Glossary of frequently used terms and abbreviations.
5. Organization of gunnery department.
6. Review and summary.

ASSIGNMENT:

A. Reference publications:

   1. Optional reading list:

      a. NavPers 10783.

INFORMATION AND DISCUSSION:

In this topic you will study the fundamentals of naval ordnance and gunnery applicable to the rating of a gunner's mate.

The terms "ordnance" and "gunnery" pertain to weapons and their use.

Ordnance comprises weapons and equipment associated with weapons. Ordnance is classified as follows:

1. Explosive ordnance.
2. Inert ordnance.

Explosive ordnance includes gun ammunition, missiles, torpedoes, mines, bombs, and rockets.

Inert ordnance includes projecting devices (guns, launchers, and release gears), protective armor, and all equipment required for weapon operation and control. Aboard ship, inert ordnance comprises all elements of ship's armament.

Gunnery is the art and science of using guns. In this Trainee's Guide, however, the term "gunnery" is used in a broader sense and includes also operation and control of all armament elements. Gunnery is principally concerned with the practical use of ordnance equipment.

Ballistics is the science of projectiles in motion. In this Trainee's Guide, unless otherwise specified, the term "ballistics" refers to the motion of projectiles fired from guns.

Ballistics is classified as follows:

1. Interior ballistics.

2. Exterior ballistics.

Interior ballistics is concerned with the motion of the projectile within the bore of the gun.

Exterior ballistics is concerned with the action of the projectile in flight.

A weapon system is a combination of a weapon (or several weapons) and the equipment which projects the destructive part of the weapon (or weapons) against the enemy. This combination enables a weapon to utilize its capabilities to the maximum.

The concept of a weapon system is relatively new and is mostly associated with modern weapons, such as guided missiles; however, certain combinations of weapons with other equipment have already been used in the past, although they were not officially designated as "weapon systems."

The following is a listing of common terms, abbreviations, and definitions which will be frequently encountered in the following text and are applicable to the rating of a gunner's mate.

GLOSSARY

AA: Antiaircraft.

AAC: Antiaircraft common projectile.

AC: Alternating current which periodically reverses the polarity of a circuit. Usually, if the value of current is plotted on a time graph, the result is a rather smooth sine wave, which is the characteristic output waveform of transformers and AC-generators. On ships, AC-supplies are normally either 60 or 400 cycles per second.

ACQUISITION: Process of accepting a target designation, acquiring a target, and initiating target tracking.

ADVANCE RANGE: Actual range combined with the corrections and predictions required to compensate for motion of own ship and of target during time of flight, plus ballistic corrections and spots.

A-END: Pump in a hydraulic power drive.

AFTERBODY: Part of a torpedo between its midship section and tail, usually containing propulsion and guidance equipment.

AIMING: Process of establishing target position in train and elevation.

AMMUNITION: Any projectile, or explosive weapon, or its components (not guns or weapon launchers).

AMMUNITION DETAILS: Components of a round.

AMPLIDYNE (GENERATOR): Trade name of a highly responsive, variable output DC generator.

AMPLIDYNE SYSTEM: System in which a small signal regulates the output of a DC amplidyne generator to control a DC drive motor.

ARMING: Setting of fuze to permit initiation. (To prevent initiation, a fuze is unarmed.)

A/S: Antisubmarine (adjective).

ASROC: Antisubmarine rocket (type of A/S weapon).

ASW: Antisubmarine warfare.

AUTOMATIC (AUTO) CONTROL: Complete and direct control of a weapon system by remote signals received from a fire control system.

AUTOMATIC GUN: Case gun in which some of the propellent energy is used to open the breech, to eject the empty case, and to load the next round.

AXIAL-PISTON PUMP: Pump consisting of a barrel which contains a group of cylinders, arranged parallel to the axis of the rotation of the barrel.

AXIS OF BORE: The extension of the central axis of the gun bore. It is tangent, at the muzzle, to the trajectory of a projectile fired from the gun.

BAG AMMUNITION: Gun ammunition with propellant in fabric bags and with separate projectiles and primers.

BALLISTIC CORRECTIONS: Corrections in range and/or deflection, to compensate for existing or possible errors caused by drift, wind, and other variations from standard range-table conditions.

BALLISTIC MISSILE: Guided missile designed to follow, for a substantial part of its flight, a ballistic (free or unsteered) trajectory.

BARREL (GUN): Part of gun structure containing the bore.

BASE RING: Base section of rotating structure of gun or rocket mount, also called deep section ring or lower carriage.

BASIC MECHANISMS: Elementary

components of machinery, also called basic machines.

BATTERY: Two or more weapons of the same design.

BATTERY ALIGNMENT: Alignment of weapons and fire control equipment in accordance with a common system of reference lines and planes, under specified conditions.

BATTLE BILL: Listing of stations to be manned under battle conditions and personnel requirements for manning those stations.

BATTLE CONTROL STATIONS: Key points of a ship's battle organization.

BATTLE TELEPHONE: Sound-powered telephone.

BEARING RATE: Rate of change of target bearing from ship, caused by relative motion of ship and target. Bearing rate may be expressed in knots (linear measure) or in degrees-per-minute (angular measure).

BENCH MARK: Reference point on own ship's structure used for aligning battery directors.

B-END: Hydraulic motor in a hydraulic power drive.

BLACK POWDER: Explosive mixture made of carbon, sulfur, and saltpeter (used as an auxiliary explosive).

BOOSTER: Rocket which furnishes thrust druing initial flight phase of a missile.

BORE: Rifled interior part of a gun barrel.

BORESAFE FUZE: Device in the exploder train that prevents a projectile from exploding until it has cleared the muzzle of the weapon.

BORESIGHTING: Adjusting sights to make them parallel with gun-bore axis or to make the lines of sight intersect the gun-bore axis at a specified range.

BREECHBLOCK: Gun mechanism element, also called plug, which blocks chamber when gun is fired.

BRISANCE: The shattering effect of a high explosive. The effect is dependent on the rapidity at which an explosive develops its maximum pressure.

BUREAU OF SHIPS TECHNICAL MANUAL: Bureau of Ships publication which contains a technical compilation on shipboard equipment, some of which is related to ordnance.

BURSTER: Bursting charge (or explosive load) in a projectile, mine, torpedo, etc., or final unit in an explosive train.

CALIBER: Unit used for measuring diameter of a projectile or gun bore. Small arms are measured to the nearest hundredth of an inch; large guns are measured in inches or millimeters. Example: In a 5"/38 caliber gun, the gun barrel caliber (diam.) is 5", and the gun barrel length is 5" x 38.

CASE AMMUNITION: Gun ammunition with propellent charge and associated components in metal or plastic cartridge case.

CHAMBER (GUN): Gun part which holds propellent charge just before gun is ready to fire.

CHASE (GUN): Outer tapering forward part of gun barrel.

CIC: Combat Information Center.

CLOSED LOOP SERVO: Servo system consisting of error-detecting device, error-signal amplifier, and servo motor. The input order signal and the response signal of the servo motor are compared by the error-detecting device. The resultant error signal is amplified to rotate the servo motor in proper direction to cancel the error signal.

COM: Common projectile.

COMPLETE ROUND: All ammunition details required to fire one shot.

COSAL: Coordinated Shipboard Allowance List, individually prepared for each ship or activity.

COOL PROPELLANT: Propellant that burns at a relatively low temperature.

COPPER FOULING: Metal residue deposited in gun bore by erosion of rotating bands.

COUNTERBATTERY FIRE: Support fire directed against enemy weapon emplacements.

COUNTERRECOIL: Movement of recoiling gun parts toward battery position, caused by a "counterrecoil mechanism" or "recuperator".

cps: Cycles per second.

CREEP: Forward movement of fuze parts when the projectile begins to slow down due to air resistance.

CROSSHAIRS or CROSSWIRES: Reticle marks consisting of a pair of perpendicular lines (horizontal and vertical).

CRT: Cathode-ray tube.

CYCLONITE: See RDX.

DC: Direct current which does not reverse the polarity of a circuit. This current may fluctuate or may be interrupted, but it always remains a direct current. (See AC.)

DASHPOT: A hydraulic braking mechanism.

DATA TRANSMISSION SYSTEM: Usually an electrical system for transmitting precise data on fire control and navigation.

DEAD TIME: Time interval between fuze setting and firing of gun.

DECKPLANE: A plane parallel to the ship's deck.

DECOPPERING: Process of removing copper fouling from gun bore.

DEFILADE or REVERSE SLOPE FIRE: Gunfire applied to shore targets located behind terrain.

DEFLECTION: Lateral angular correction applied to the target bearing to obtain a correct gun order.

DEGREE OF READINESS: Status of ship's complement, plant, and armament under specified conditions.

DEPTH CHARGE: A/S weapon dropped aft or projected from surface vessel.

DETONATION: Violent chemical action (oxidation and recombination) initiated by a shock which produces a shock wave, heat, and gases.

DETONATOR: Initiating device in an explosive train.

DIFFERENTIAL: (1) CYLINDER: Piston-cylinder (hydraulic device) which develops either equal thrust with unequal pressure or unequal thrust with equal pressure. (2) MECHANICAL: Gear arrangement which adds or subtracts mechanical inputs. (3) SYNCHRO: Either one of the two types of synchros used to obtain a mechanical or electrical difference between or sum of two inputs.

DIRECT FIRE: Gunfire aimed directly at target ashore when target is visible to firing ship.

DIRECTOR: Fire control unit that establishes location of target.

DISPERSION OF SHOT: Distance or impact point of shot from the mean point of impact of the salvo. Dispersion in range is measured parallel to the line of fire; dispersion in deflection is measured at right angles to the line of fire in a horizontal plane.

DOUBLE-BASE POWDER: Solid rocket-propellant, composed mainly of nitrogylcerin and nitroguanidine.

DOUBLE-SPEED SYNCHRO OPERATION: Use of two parallel synchro systems. To achieve greater accuracy, one is usually operating at a 1 : 1 ratio with input, and the other at a 36 : 1 ratio with input.

DREDGER HOIST: Type of ammunition hoist used between ammunition handling rooms.

DRIFT: (1) Deflection of projectile trajectory by interaction of gravity, air resistance, and projectile spin. (2) Rate at which water current moves a ship with respect to land.

DUMMY or DRILL AMMUNITION: Ammunition without explosives or propellant.

ELECTRICAL FIRE: Primer firing by means of electricity.

ELEVATING ARC: Gear sector on slide used to to elevate guns.

ELEVATING GEAR: Mechanical, hydraulic, and electrical equipment used to elevate weapons.

ELEVATION: Movement of weapon in a plane perpendicular to the deck, also called pointing.

ELEVATION ALIGNMENT: Adjusting of fire control and weapon system elements to make them parallel and at exactly the same angles to a selected horizontal plane.

ELEVATION RATE: Rate of change of target elevation (position angle) in degrees-per-minute.

EMF: Electromotive force, usually equivalent to voltage.

ENFILADE FIRE: Gunfire applied to target whose long axis is parallel to the line of fire.

EROSION (GUN): Wear inside a gun bore.

ERROR SIGNAL: Difference between order signal and response signal in a servo. Error signal is fed into the servo amplifier.

ESR: Equivalent service rounds. Standard unit of measurement for determining number of rounds fired, to estimate resultant wear of gun.

EXERCISE HEAD: Forward section of torpedo, loaded with inert liquid, expelled at the end of the torpedo's run to make the torpedo float.

EXPLODER: In a torpedo, equivalent to projectile fuze.

EXPLOSION: See DETONATION.

EXPLOSIVE: Any material that can detonate.

EXPLOSIVE D: Ammonium picrate, a nonsensitive explosive.

EXPLOSIVE TRAIN: Group of explosive units designed to function in sequence.

FEEDBACK (SERVO): Servo output signal fed back to input, to regulate servo action.

FIN-STABILIZED ROCKET: Rocket stabilized by aerodynamic surfaces on its tail.

FIRE CONTROL: System controlling the armament of the ship.

FIRING STOP MECHANISM: Device preventing own ship's weapons from firing into own ship's structure.

FIRING LOCK: Part of gun (a mechanical unit) housing the firing pin (or striker) which contacts (or strikes) the primer.

FIRING PIN: Metal pin that can fire primer by electrical contact and/or by percussion.

FIXED AMMUNITION: Gun ammunition of which each round constitutes a single unit.

FLAREBACK: Ignition of residual vapors in a gun bore after firing. These vapors ignite as they come in contact with air when breech is opened.

FLUID: Substance in liquid state that continuously takes the shape of its container. (The term "fluid" means the same as "liquid.")

FOLLOW-UP SYSTEM: See SERVO.

FORCE: Power which causes (or tends to cause) an object to move or, if object is moving, to change its direction or rate of motion.

FOUL BORE: Gun bore containing residual gases after firing. In small arms, a bore contaminated by excessive solid residue.

FREQUENCY: Number of vibrations per time unit (usually per second).

FUZE: Mechanical, electrical, electronic, magnetic, or combination device used to initiate the first element in an explosive train of a projectile at the proper time and under certain circumstances. (A fuze is designed to prevent initiation at other times.)

FUZE SETTER: Device for adjusting time fuzes just before firing.

GFCS: Gun fire control system.

GIMBAL: Metal ring or similar support rotating freely on a pivot.

GMLS: Guided missile launching system.

GUN FIRING: Process of shooting a gun (or guns).

GUNNERY: Operation and control of all armament elements.

GUNNERY DOCTRINE: General instructions on course of actions to be taken by officers supervising weapon operations in specified tactical situations.

GYROSCOPE (GYRO): Device using the rotational inertia of a spinning wheel to establish a reference direction (or plane) in space, or to provide displacement in another direction proportional to any force that tends to twist the axis of the wheel.

HAND CONTROL: On certain electric-hydraulic gun-mount power drives, mechanical-hydraulic servo controlled by mount personnel.

HANDLING ROOM: Compartment aboard ship used for transporting and, to a certain extent, for stowing ammunition.

HANGFIRE: Accidentally delayed ignition of primer, igniter, or propellent charge.

HIGH EXPLOSIVE: Any detonating compound or mixture, such as Explosive D, TNT, RDX, HBX, etc.

HOLDING-DOWN CLIPS: Parts that prevent base ring from being tipped out of the training circle.

HOMING: Final stage of a homing torpedo's run in which it steers itself toward a detected target, also applies to other target-seeking devices.

HORIZON CHECK: Comparison of elevation dial readings when battery element is laid successively on a series of points on the horizon.

HORIZONTAL PLANE: Plane tangent to the earth's surface or parallel to such a plane.

HOUSING (GUN): Main support of recoiling gun parts; also houses breech mechanism.

HUNTING: Tendency of servo system output to oscillate due to weak signal, insufficient feedback, excessive gain, or other malfunction.

HYDRAULICS: Study of action of liquids under pressure in enclosed systems. In this course, the study is expanded to include action of liquids at rest in open systems (hydrostatics).

HYDRAULIC SPEED GEAR: Combined A-end and B-end, with associated piping and other components.

IGNITER: Unit in propellent train which sets off the propellant.

ILLUMINATING PROJECTILE: Projectile containing a chemical flare and parachute. (Abbreviation: Illum.)

IMPULSE CHARGE: Propellent charge consisting of black powder, formerly used to eject depth charges and torpedoes from their launching devices.

INDEX OF PROPELLANT: Blend of several lots of propellant powder.

INDICATOR RECEIVER REGULATOR (usually called INDICATOR-REGULATOR or RECEIVER-REGULATOR): Equipment which controls weapon-mount power drives.

INDIRECT FIRE: Fire delivered onto a target ashore which is not visible from the ship and therefore cannot be used as a point of aim.

INITIAL BALLISTIC CORRECTION: Ballistic corrections which are not automatically compensated for by the fire control system.

INTERMEDIATE CALIBER (GUN): Gun whose caliber exceeds 4 inches, but is smaller than 8 inches.

JAN: Joint Army Navy.

LADDERS: Method of spotting target by opening fire short of target and then increasing range in steps larger than pattern size.

LINER: Cylindrical insert in gun tube. In some guns, insert is engraved with rifling grooves.

LOCAL CONTROL: Control of a gun by means of signals originating in the mount.

LOS: Line of sight.

LOW-SPEED SYNCHRO: Synchro rotating at 1 : 1 ratio with input, also called coarse unit.

MACHINE: Mechanical system employing one or more basic mechanisms.

MAGAZINE: Compartments aboard ship designated for ammunition stowage.

MAGAZINE SAMPLES: Propellant samples used for checking smokeless powder for decomposition. These samples are kept in airtight bottles containing chemical indicator paper strips impregnated with 1/10 normal methyl violet.

MAJOR CALIBER (GUN): Gun of 8-inch or larger caliber.

MANUAL CONTROL: Positioning of ordnance equipment without use of power units.

MEAN BATTLE RANGE: Range at which a gun is most effective. At this range gun sights may be boresighted.

MECHANISM, BASIC: Mechanical component, such as a lever, gear, pulley, etc.

MERRY-GO-ROUND: (1) Drum magazine in rocket launcher Mk 108. (2) Rotating cage used for ammunition transfer in certain 5-inch gun mounts.

MFCS: Missile fire control system.

mil: Unit of angular measure used in naval gunnery to specify sight deflection. One mil is the angle whose tangent is 0.001 (arc tangent 1/1000).

MINOR CALIBER (GUN): Gun whose caliber exceeds 0.60 inch, but is less than 4 inches.

MISFIRE: Failure of primer to ignite when firing action is initiated.

MOUNT (GUN): Structure which supports gun and enables it to be elevated, trained, and fired.

MPI: Mean point of impact, geometrical center of all points of impact in a salvo.

MTF: Mechanical time fuze.

MULTIBASED POWDER: Gun propellant composed of one or more explosive constituents in addition to nitrocellulose.

NAVORD LISTS: Navy Ordnance Allowance Lists.

NEUTRALIZATION SUPPORT FIRE: Support fire intended primarily to hamper or prevent enemy movement of action.

NOMINAL INITIAL VELOCITY: Initial velocity assigned to a new gun with propellant temperature at 90°F.

NONAUTOMATIC (GUN): Gun which does not use the energy of a propellant to perform breech operations or ammunition loading and ejection.

NONFRAG: Nonfragmenting projectiles used in AA-gun practice which produce colored smoke (but no fragments) when they detonate.

NOSE CAP: Armor-penetrating part of armor-piercing projectile.

NUCLEAR (ATOMIC) WEAPON: Explosive device using nuclear reactions as source of disrupting energy. (In context, the term "special weapons" means nuclear weapons.)

NULL: In servo terminology, "zero" implies complete absence of a signal; "null" implies that there is no perceptible signal, although noise and random nonsignal voltages may be present.

OFFSET CENTERLINE: In drydock battery alignment, a line established ashore, parallel to the drydocked ship's centerline.

OP: Ordnance Pamphlet (technical manual).

ORDALT: Ordnance Alteration, a prescribed change in ordnance equipment.

ORDER SIGNAL: Control signal received from outside the servo.

ORDNANCE: Weapons and their associated equipment. Aboard ship, ordnance includes all elements of ship's armament.

ORDNANCE ALLOWANCE LISTS: Lists of required ordnance materials for naval organizations afloat and ashore.

ORIGIN OF RIFLING: Start of rifling land, just forward of chamber.

OVEN TEST: Method of testing smokeless powder by heating it in an oven.

PARALLAX: The resulting angular difference between observations or computations of one target from two different stations. Horizontal (train) parallax is the angular difference measured in horizontal plane; vertical (elevation) parallax is the angular difference measured in vertical plane.

PARALLAX ERROR (TELESCOPE): Deceiving target displacement when the eye is shifting around the optical axis of the eyepiece of the telescope.

PATTERN OF SALVO: In range, distance measured parallel to the line of fire between the shot falling (or bursting) at the greatest distance from the firing point and the shot falling (or bursting) at the shortest distance (except wild shots). In deflection, distance measured at right angles to the line of fire between the shot falling (or bursting) at the greatest distance to the right, and the the shot falling (or bursting) at the greatest distance to the left (except wild shots).

PDF: Point-detonating fuze.

PERCUSSION (FIRE): Firing a primer by mechanical impact.

PHASE: Angular relationship between two alternating currents or voltages. For instance, between a signal voltage and a reference voltage, when the voltage or current is plotted as a function of time. When both voltages are in phase, the angle is zero, and both voltages reach their peaks of value simultaneously; when the voltages are out of phase, one of them leads or lags the other. At the instant when one voltage reaches its peak, the other may not be at its peak and (depending on the phase angle) may differ in polarity as well as in magnitude.

PLASTER-LOADED or SAND-LOADED AMMUNITION: Similar to service ammunition, except for inert load instead of burster.

PLUG: See BREECHBLOCK.

PLUG GAUGE: Instrument used to check adequacy of clearance in gun bore.

POINT OF AIM: Point on a target to which sight is directed.

POINTER: Person who moves a weapon in elevation.

POWDER FOULING: Propellant residue in gun bore and chamber after firing.

PREDICTING: Process of determining future target positions. Predicting operations are accomplished by using computers during tracking.

PRESENT RANGE: Best available measurement of target range.

PRIMARY EXPLOSIVE: Very sensitive explosive, such as mercury fulminate, DDNP, lead azide, lead styphnate, tetracene.

PRIMER: First unit in a propellent train.

PROGRAMMING: Setting up automatic equipment to perform certain operations in proper sequence.

PROJECTILE: Component of gun ammunition which is expelled from the gun by force of burning propellant.

PROPELLING CHARGE (PROPELLANT): Any mixture or substance that burns rapidly (usually incorporating most of its oxygen), but does not detonate; commonly used to propel rockets, gun projectiles, etc.

PROTOTYPE: Early (usually first) equipment model used as example for mass reproduction.

PYROTECHNICS: Munitions designed to produce light or smoke for illumination and/or signaling.

RANGE-TABLE INITIAL VELOCITY: Initial velocity for which the range table is computed.

RANGING: Process of establishing distance of target from firing ship.

RDX: High explosive. Main constituent of compositions A, B, and C. (For detailed description, see appropriate OP.)

RF: Rapid fire. In RF-guns, loading, firing, empty-case ejection, and breech operations are performed automatically by means of power received from another source than from the propellant.

RECOIL: Rearward thrust of gun caused by firing of gun, also movement of gun parts in response to this thrust.

RECOIL MECHANISM: Mechanical or hydraulic brake that absorbs a certain amount of recoil energy.

REFERENCE PLANE: Arbitrarily chosen plane, usually within the ship, from which the relative elevation angles of all battery elements are measured. It may be the plane containing one of the battery roller-paths, the ship's deck, or an imaginary (nonexistent) plane.

REFERENCE SUPPLY: AC voltage of specified frequency and phase, supplied to energize synchro and servo systems. Reference frequencies are usually 60 cps and 400 cps.

REFERENCE VOLTAGE: Ship's AC supply, used to energize power supplies and servo-motor fields.

RELIEF VALVE: Valve that automatically opens to relieve excessive pressure. (A safety valve is also a type of relief valve.)

RESPONSE: In a servo, the movement or signal effected by servo operation. This signal, also called feedback, is fed back into the error-sensing device.

RESTRICTED WEAPONS: Atomic, biological, and chemical weapons, also called ABC-weapons.

RIFLING: Spiral grooves in the inner surface of the gun bore.

ROLLER PATH: Roller bearing on which a weapon mount or fire-control element is trained.

ROLLER PATH COMPENSATOR: Mechanical device which automatically introduces a compensating tilt at all train angles, to correct tilt of roller path.

ROTATING BAND: Raised copper band, near the aft end of the projectile, that imparts rotation to the projectile as it passes through the gun bore.

SALVO: Two or more weapons fired at the same time.

SALVO LATCH: Mechanical interlock designed to prevent accidental opening of gun breech in event of misfire or hangfire.

SEAPOWER: That portion of a nation's overall power which enables it to control the sea in furtherance of its interests, objectives, and policies.

SEMIAUTOMATIC (GUN): Case gun in which some of the propellent energy is used to open the breech, to eject the empty case, and to close the breech when the next round is loaded.

SEMIFIXED AMMUNITION: Two-piece gun ammunition. Each round consists of a primed propelling charge in a metal case and a projectile.

SERVICE AMMUNITION: Complete ammunition assemblies fit for service.

SERVO SYSTEM or SERVO: System in which a relatively powerful driving unit responds to a relatively weak signal. The response is fed back to the sensing device at the input-end of the system and is compared with the incoming signal; the operation of the driving unit is controlled in correspondance with the signal. A servomechanism, also called a follow-up system, is a type of servo system with mechanical components which may be driven by an electrical servo motor.

SERVO MOTOR: Unit of servo system that drives the load, especially the electric-drive motor in a servomechanism or in the gun elevation or training gear.

SETBACK: Force of inertia that tends to move fuze parts to the rear when a projectile or rocket is fired. Setback is often used as the first step of arming.

SIGHT: Optical device that establishes line of sight (LOS) to target and provides for positioning of weapon or director with respect to LOS.

SINGLE-BASE POWDER: Gun propellant containing only one explosive ingredient, nitrocellulose.

SINGLE-SPEED SYNCHRO OPERATION: Use of one synchro system to transmit shaft rotation data at a 1 : 1 ratio with original signal.

SLIDE: Structural support for all gun mount parts that move in elevation.

SLIDE CYLINDER (GUN): Cylindrical after part of barrel.

SLIPRING: Rotating annular contact.

SMALL ARMS (CALIBER): Arms whose caliber is 0. 60 inch or smaller.

SOCKET RING: Part of an axial piston pump which can be adjusted to regulate pump output.

SPCG: A multibased smokeless powder which contains nitroglycerine.

SPENT BRASS: Used cartridge cases.

SPOT: Correction to be applied to gun position in order to hit target.

SPOTTING: Estimating required correction in range, elevation, deflection, and fuze range, in order to hit target. (A spotter is a person who observes the fall of shot (or burst) and estimates the required corrections; a spot is the required correction estimated by the spotter.)

SS: Star shell, an illuminating projectile.

STABLE ELEMENT: Gyroscopic device which maintains a horizontal reference plane. (Related device for vertical reference plane is called stable vertical.)

STAND: Foundation of gun or rocket mount. It incorporates training circle and is secured to ship's structure.

STAR GAUGE: Instrument for measuring wear in gun bore.

STAR SHELL: See SS.

SURVEILLANCE TEST: See OVEN TEST.

SYNCHRO: Electro-magnetic device used primarily for transfer of angular-position data.

SYNCHRONOUS MOTOR: AC-motor designed to operate "in step" with the AC-supply; hence, it has a constant-speed characteristic, with its accuracy limited only by the steadiness of supply frequency.

SYSTEM ALIGNMENT: Adjustment of two or more major components of a weapon system to ensure proper geometrical relationship.

TARGET-GRID SYSTEM: Method of using a grid-spot converter, to make the spots observed by shore fire control parties available without delay to the ship's fire control systems.

TACHOMETER GENERATOR: Generator whose voltage output is directly and precisely proportional to its rate of rotation. A tachometer generator is frequently used as a damping generator.

TACTICAL MINING: Mining performed in connection with a specific naval operation.

TOMPION: Plug inserted in gun muzzle to protect bore.

TARGET ACQUISITION: Process of positioning the tracking apparatus of a control system so that a designated target is gated in the radar, optical devices, or open sights.

TARGET ANGLE: Relative bearing of own ship from the target, measured horizontally from bow of target, clockwise from 0 to 360 degrees.

TARGET DESIGNATION: Selection of targets to be taken under fire and transmission of information required for acquisition to the selected fire control station (or stations). The target designation types and methods are as follows:

A. Target designation types are classified according to the stations originating the designations:

1. Command designation -- Designation of a target by a command station.

   a. OTC (Officer in Tactical Command) designating vessel to take target under fire.

   b. CO (Commanding Officer) of vessel designating target to be taken under fire.

2. Control designation -- Designation of a target from a fire control station.

3. Local designation -- Designation of a target by personnel of mount or turret.

B. Target designation methods are classified according to designation procedures.

1. Automatic designation -- Designation of target by means of instruments which transmit sufficient data to the selected gunfire control system for target acquisition.

2. Partially automatic designation -- Designation of target by means of a partially automatic system which must be coached, in order to position the selected director to acquire the target.

3. Verbal designation -- Oral designation of target (by voice or telephone).

TARGET EVALUATION: Estimates of target intent, degree of threat, and type of attack to be delivered, based on plots of target position.

TETRYL: Aniline-based organic compound, a high explosive.

THROWN WEAPONS: Small contact- or proximity-fuzed A/S explosive devices thrown by a rocket or mortar from attacking surface vessels.

TIME OF FLIGHT: Time interval from firing of projectile until its impact or explosion.

TNT: Trinitrotoluene, a high explosive.

TRACER: Pyrotechnic device on projectile which shows flight path of projectile.

TRACKING: Process of establishing path of a moving target with respect to firing ship, accomplished by computing the data obtained through aiming and ranging processes.

TRAIN: Movement of weapon in azimuth.

TRAIN ALIGNMENT: Alignment of fire control and weapon system elements to make them parallel and at exactly the same angle to a selected vertical plan.

TRAINER: Person who trains a weapon.

TRAINING CIRCLE: Internal gear inside the stand.

TRAINING GEAR: Mechanical, electrical, and hydraulic equipment used for training weapons.

TRAMMING: Procedure for checking train and elevation dial-accuracy of gun mounts.

TRANSMISSION CHECK: In fire-control system alignment, process of checking if data-transmission system is functioning with required accuracy.

TILT BOX: Part of axial-piston pump containing socket ring.

TRITONAL: Mixture of TNT and aluminum powder.

TRUNNIONS: Part of gun-mount slide, center of rotation during elevation.

UFCS: Underwater fire control system.

ULTRASONICS: Sound above range of frequencies audible to normal human ear.

UPPER CARRIAGE: Part of the rotating structure of a gun mount which contains the trunnion bearings.

VT: Proximity fuze.

WARHEAD: Forward section of torpedo or missile laden with explosives.

WEAPON: Destructive unit of a weapon system, except guns, capable of destroying the target (usually by explosion).

WEAPON SYSTEM: Combination of weapon (or weapons) and equipment which project the destructive part of the weapon (or weapons) against the enemy. The functions of a weapon system are as follows:

1. Detects, locates, and identifies the target.
2. Delivers or starts delivery of weapon to target.
3. Controls delivery unit and/or weapon.
4. Destroys the target.

W Q & S BILL: Watch, Quarter, and Station Bill, a chart showing for each billet the name and rating of person assigned, cleaning and maintenance station, and assignments to condition watches and specific bills.

* * * * * * * *

The following discussion will cover a ship's gunnery department organization.

Upon completion of this course, you will be ordered aboard ship. After reporting aboard, you will be assigned to one of the divisions directly associated with ship's armament. Your job will be to assist, under supervision of a petty officer, in the care and maintenance of the armament of your division.

The gunnery department of combat vessels whose main armament consists of guns is headed by the gunnery officer, who, in turn, is responsible to the captain.

The gunnery department consists of several divisions which are designated by special letters or numbers. Each division is headed by an officer responsible to the gunnery officer.

The illustration on the following page shows a typical gunnery department organization of large combat ships (such as cruisers and frigates). The first and second divisions (sometimes also the third division) man the main battery (gun mounts or turrets) or, on guided missile vessels, the guided missile launchers; the third and the fourth divisions man the secondary battery (5-inch dual-purpose mounts); the fifth and the sixth divisions man the 3-inch AA mounts.

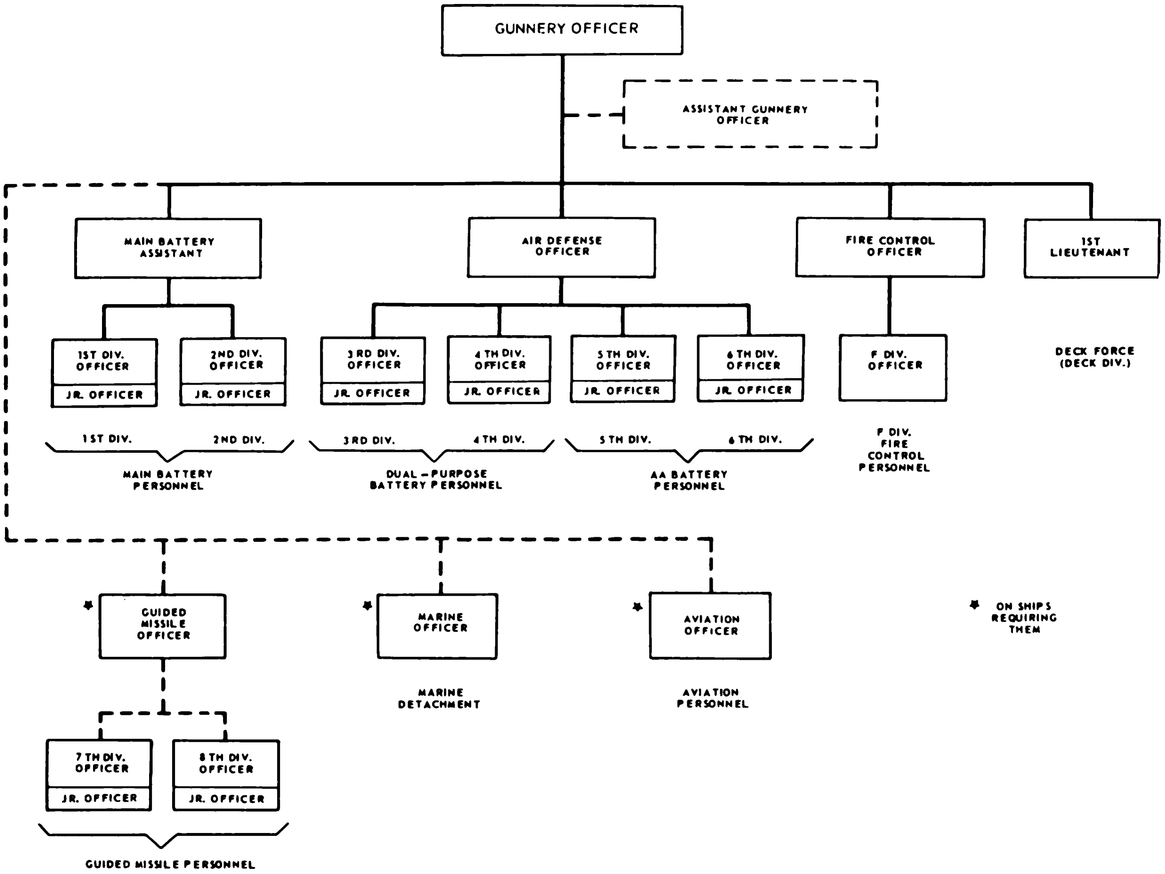
On guided missile cruisers which also carry gun turrets, the first and the second divisions man the turrets, while the seventh and the eighth divisions man the missile launchers and their weapon control systems.

The F-division personnel man the gunfire control equipment and the plotting rooms; on ships which have two fire control divisions, the FA-division mans the AA fire control system, and the FM-division mans the main battery system.

As shown on the diagram, each division has a division officer and usually a junior division officer assistant. Most of the division officers do not report to the gunnery officer directly, but through an additional echelon. The officers of the first and of the second divisions are under command of the main-battery assistant; the officers of the third through sixth divisions are under the command of the air defense officer; the officers of the F-division are under command of the fire control officer.

However, illustration #2-1 is not to be considered a complete organizational chart: Certain technical personnel (such as warrant gunners) are omitted, and functional relationships are not shown. Also, the assistant gunnery officer may perform double functions (may act as one of the battery or division officers).

On small ships, the gunnery department organization follows the pattern of larger ships. However, since small ships have fewer of-



2-1. TYPICAL GUNNERY DEPARTMENT ORGANIZATION OF A LARGE COMBAT SHIP (SIMPLIFIED SCHEMATIC)

ficers and, relatively, a greater variety of armament than large ships, some of the billets are expanded to cover more functions.

To fully understand your ship's organization, if you have any questions, do not hesitate to ask the petty officers of your division.

NOTE: All manuals, illustrations, and charts will be useless, unless your gun, mount, or missile launching system is always in top condition; planning, training, and drills will all be just a waste of time, if your guns fail to operate at the right moment. It's up to you to keep 'em firing.

TOPIC 2: IDENTIFICATION AND CARE OF ORDNANCE EQUIPMENT

You Are Now Going To Learn:

1. The identification and care of ordnance equipment.

Discussion Points For This Topic Are:

1. Importance of identification of ordnance equipment.
2. Nomenclature used for identifying ordnance equipment.
3. Means of identification.
4. Maintenance of ordnance equipment.
5. Ship's Navy yard and tender availability periods.
6. Review and summary.

INFORMATION AND DISCUSSION:

In order to be able to identify ordnance equipment, it is important that every gunner's mate be familiar with the basic principles of naval classification and cataloguing systems.

Classification and cataloguing of ordnance equipment was necessitated in the 20th century by the development of numerous and complex weapons. Since the methods applied by the Navy for identification of ordnance equipment are extremely complex, it would not be possible to furnish in this topic a detailed description of the classification and cataloguing systems used. The following text will cover only the fundamentals of these systems, applicable to a gunner's mate's rating.

Nomenclature:

The standard nomenclature for an item of naval ordnance equipment usually consists of a basic title (name), frequently accompanied by a brief description and identifying numbers.

Example:

3-inch 50-cal. rapid-fire twin gun mount Mk 33 Mod 4

"3-inch" specifies the bore diameter (caliber).

"50-cal." specifies barrel length in terms of caliber. Since this is a 3-inch 50-caliber gun, its length is 3 x 50 = 150 inches.

"rapid-fire" indicates that the ammunition is fed into the gun automatically by a power-driven loader.

"twin" indicates that the mount assembly incorporates two parallel gun barrels.

"mount" is the basic title (name). A mount includes not only the guns with their training and elevating gear, but also the shield, power drives, power rammer and loader, and sighting equipment.

"Mk 33 Mod 4" is the abbreviation for Mark 33 Modification 4, which specifies a particular design of a certain mount.

In the Navy identification system, the modifiers in the nomenclature of an item are used rather flexibly; thus, for instance, an ordnance technical manual (OP) may refer to the gun mount mentioned previously merely as "3-in. mount Mk 33 Mod 4." Note that the word "gun" is omitted; when not otherwise specified, "mount" always means a gun mount.

The mark number identifies a major item (for instance, a gun mount) or a principal component (for instance, a sight or a power drive) of a particular equipment design.

When the Navy makes a major change in design (or designs) of new equipment of the same type, the basic title of the equipment remains the same, but the mark number is changed. Thus it is clear that, for instance, the Mk 33 Mod 4 twin mount has a different design than the Mk 34 single mount or the Mk 27 twin mount. (The design of the Mk 27 gun differs significantly from the one of Mk 33 in the design of the slide.)

The mod number ("Mod" is an abbreviation of modification, not model) indicates a minor change in design or an alteration. For example, the Mk 33 Mod 4 mount, mentioned previously, differs from the Mk 33 Mod 2 mount mainly by the feature that the Mod 4 has an aluminum shield, while the Mod 2 does not have one.

Mod numbers may also be changed because of improvements made in equipment design or adaptation of the equipment for mounting it in a different place on the ship, or for the operation with a different associated equipment.

The nomenclature of naval guns or mounts always includes their calibers. Special series of mark numbers are used for each caliber; for instance, all 5-inch guns are numbered in the same series regardless of their bore length. Thus, all 5-inch guns (5"/51, 5"/25, 5"/38, and 5"/54) and their mounts are numbered in a single series of mark numbers.

The nomenclature, mark numbers, and mod numbers for each item of ordnance equipment are assigned by the Bureau of Weapons. The nomenclature of major units is listed in the current edition of OP 0. Nomenclatures of separate units or their components which have mark and mod numbers are listed in the applicable OP or the ordnance supply catalog of the particular equipment.

Gun mounts are identified not only by mark and mod numbers, but also by assembly numbers. This identification system is used because gun mounts (especially large ones) are not single units, but actually combinations of smaller units each of which has already its own mark and mod number. For instance, the 5-inch mount Mk 39 Mod 0 may be equipped with an elevation indicator-regulator Mk 54 of any of a number of mods or with a train indicator-regulator Mk 46 of any of several mods; it may also have a shield Mk 54 Mod 0 or Mk 54 Mod 1, etc. Actually, there are 19 types of similar assemblies designated "5-inch mount Mk 39 Mod 0."

To ease identification, each individual unit of equipment which has a mark and mod number also has its own serial number.

In accordance with Navy standards, weapon systems, fire control equipment, and their principal components are usually identified by mark and mod numbers.

Certain Navy ordnance equipment, such as small-arms weapons and ammunition procured from the Army, normally retains the Army designation which consists of the letter "M" (standing for model) followed by a number (corresponding to the Navy mark number). If there are modifications, this number is followed by the letter "A" (standing for alteration) followed by a number designating the mod. Thus, "carbine, cal. .30 M 3 A 1" means a certain carbine with a 0.3-inch bore which would correspond, in Navy terminology, to the Mk 3 Mod 1.

Aircraft bombs which have been jointly adopted by Air Force and Navy are identified by "AN" followed either by Army-style identification (M_A_) or by Navy mark and mod numbers.

Units, components, and parts of major assemblies are identified by the numbers that appear on the drawings prepared by their manufacturer.

For example, Bureau of Ships drawing number S2407-F-3235506 shows a complete compass-repeater mechanism which is identified as Ship's Course Indicator Mk 6 Mod 5A. On this drawing, all parts which constitute the unit are also identified. Furthermore, it is indicated how to assemble the complete unit and of which material the individual parts are made by reference to the specification publication.

NOTE: A specification is a Government-issued publication which lists the requirements that a certain part or material must meet in order to be accepted by Government inspectors when it is delivered under contract to a Government agency.

The same drawing, mentioned previously, also contains three detailed views of the complete assembly: A plan view of the top, a view of assembly in elevation (partly cut away), and a horizontal cross-section view on which each subassembly and part is labeled.

Since the compass-repeater mechanism is a relatively simple device, the complete unit can be shown on one sheet. More complex assemblies, however, may require several sheets which also are identified by the same number. Separate drawings are required for subassemblies and individual parts. The subassemblies and their parts are then, in turn, identified by their drawing numbers.

Each ship carries technical manuals on maintenance and operation of equipment installed on it. These manuals contain reproductions of engineering drawings which show the equipment described. In addition, ships also maintain files of full-size or reduced prints made from original drawings. These files are kept in the gunnery department.

When replacement parts are ordered, the drawing number should be crossindexed and changed to a Federal stock number. The Navy material catalogs issued by various Navy activities, such as the Ordnance Supply Office or Electronics Supply Office, list the stock numbers together with the drawing numbers. When non-Federal stock items are requested, the name, drawing number, and mark and mod numbers of the item and associated equipment, and all other pertinent information should be furnished.

Standard hardware (common nuts, bolts, flat washers, and grommets) and standard electrical units (fixed capacitor, lamps, electronic tubes, and fixed resistors) are identified in Navy material catalogs by standard letter-number combinations.

Each major item which is assigned a mark and mod number (or the equivalent) bears a metal nameplate secured to some easily visible place on its outside. This plate is engraved (or printed) to provide the following information:

1. Standard nomenclature of the equipment, including the mark and mod number (or equivalent) and identification number of the system of which it is a part (unless item is a complete, selfcontained unit).

2. Standard Navy stock number, Federal stock number, or other catalog identification number.

3. Name of cognizant bureau.

4. Manufacturer's part number or drawing number.

5. Name of manufacturer.

6. Number of contract under which item was manufactured.

7. Serial number, assembly number, or other numbers which identify the specific unit. (Items produced in large quantities may have lot numbers instead of assigned serial or other numbers.)

The name plate may also contain other information, such as voltage and frequency of electric power to be supplied to the unit, safety precautions to be observed while operating the unit, blank space for recording alterations that have been made, etc. Since equipment procured by various Navy activities may be slightly different, the name plate is always the best primary source of identification.

Name plates should never be detached, obliterated, or permitted to become illegible, either through accumulation of grime and dirt, or by being painted over, or by overscouring which would erase the information. The information contained on the name plate should never be changed or additional data added, except when specifically directed to do so by the cognizant bureau.

Many small assemblies and parts are identified by special numbers or coded markings. The numbers may be Navy catalog numbers or contractor drawing numbers; the code markings may consist of symbols used on the schematics. To facilitate identification of individual parts, it is therefore important to have the technical manual or instruction book for the particular equipment, and, if possible, the appropriate part of the Navy material catalog and the available prints or drawings.

The information needed for identification of ordnance equipment depends upon the specific purpose. For example, for identifying the entire equipment as a functional unit, the name, mark number, and mod number are sufficient; but for requesting spare parts from the Bureau of Ordnance, the serial number (and the assembly number, if any) may also be necessary. (This combined information enables the factory or depot to identify the equipment by using its manufacturing records.)

Maintenance:

Aboard ship, maintenance work consists mainly of upkeep which includes preventive maintenance, repairs, and alterations.

Most of the modern ordnance equipment is extremely complex and requires frequent periodic checks, exercising, tests, painting, corrosion-proofing, lubrication, and adjustments to keep it in proper operating condition. This daily and weekly work is called preventive maintenance, because it is performed in order to discover and to eliminate possible sources of trouble, to prevent actual trouble from occuring. Check-off lists containing detailed descriptions of the work to be performed daily, weekly, monthly, etc., are issued by type commanders.

With each ordnance installation, the Bureau of Weapons furnishes publications which outline the maintenance procedures. (These publications will be discussed in the following topic.)

In Navy Regulations, repair is defined as follows: "Work necessary to restore a ship or an article to serviceable condition without change in design, materials, number, location, or relationship of the component parts."

Repairs include troubleshooting and replacing or restoring of equipment or parts to serviceable condition. Operational failure of equipment may be caused by wear, rust, or corrosion, by malfunction of some other part of equipment, by personnel error, or by enemy action.

Repairs may be performed by the following three activities:

1. Ship's force.

2. Repair ships (tenders).

3. Naval shipyards.

Repairs, as mentioned previously, do not include changes made to improve equipment. Such changes are called alterations.

According to Navy Regulations, an alteration is "any change in the hull, machinery, equipment, or fittings which involves a change in design, materials, number, location, or relationship of the component parts of an assembly regardless of whether it is undertaken separately from, or incidental to, or in conjunction with, repairs."

No alteration may be performed on any ship or article on board without authorization from the bureau concerned. Alterations to modify ordnance equipment which change the characteristics of a ship may be authorized only by the Chief of Naval Operations and are issued by the Bureau of Weapons. These authorized alterations are serially numbered as NavAlts.

Authorized alterations to ordnance equipment which do not change the characteristics of a ship are issued by the Bureau of Ordnance and are serially numbered as OrdAlts.

Both NavAlts and OrdAlts contain complete descriptions of the changes to be incorporated, information about the purpose and priority of the alterations, name of agency which will perform the work, procurement of material, disposal of discarded material (if any), and all necessary plans, diagrams, and specifications.

Repairs and alterations are sometimes interwoven: Certain repair operations involve more than just restoration of equipment to operating conditions without changing its original design. For example, a defective part may be replaced by a part of different material or of more efficient design, or certain parts may be strengthened, or minor changes may be made to prevent recurrence of certain casualties or to prevent damage to the ship's structure. These operations are called alterations equivalent to repair. However, alterations equivalent to repair should never increase the original weight of the unit.

The ordnance machinery history is one of the most important records of the gunnery department. The gunnery officer is responsible for keeping these records complete and up-to-date. The records are kept on standard looseleaf form cards in a hard binder. The entries must include the following information:

1. Major repairs performed.
2. Parts replaced.
3. Material failures.
4. Modifications (OrdAlts).
5. Number and type of rounds fired.
6. Bore-erosion and star-gauge data.
7. Name-plate data.

A battery log (record book) is kept on each 3" rapid-fire mount and larger mounts. (3" semiautomatic single guns and smaller guns require only one log book for each battery.) It is the responsibility of the leading gunner's mate assigned to the equipment that the daily entries in the logs are made. The entries must include the number and type of rounds fired, casualties, repairs, tests, alterations, and special (not routine) maintenance performed. The logs must also include all mark, mod, and serial numbers of the equipment.

Most of the maintenance work aboard ship is accomplished by the ship's force (naval personnel). Gunner's mates are usually proud of the amount of work the ship's force can perform without formal aid from tenders or shipyards; the more maintenance work the ship's force can do, the better the condition of ship and equipment will be, and the better the crew will get to know the ship and equipment.

However, the extent of repairs that can be performed on a small ship is limited by lack of proper facilities and skilled personnel. A repair ship has more elaborate repair facilities; the personnel are experienced in repair work and are capable of performing most of the major repairs.

Naval shipyards, of course, are capable of handling all major repairs; therefore, every ship is regularly assigned a tender-availability or yard-availability period, which means that the vessel can tie up to a tender or go into a yard for a specified period and have the work done that is beyond the capacity of the ship's force or cannot be performed while the ship is in operation. Such work generally includes major repairs, overhaul of hull, superstructure, machinery, or armament for which the ship's force has neither tools nor skill. In gunnery department installations, an example of such work can be the replacement of a main-battery director or lifting out of a 5"/38 twin mount to substitute parts of its training circle or roller path.

Every important repair or alteration job must be performed during the availability period. Shipyards and tenders are always busy and have plenty of work to do; once the ship's availability period is over, she cannot come back a day or two days later because some job wasn't completed or was overlooked.

During the ship's availability periods, the department head and leading gunner's mate keep track of all maintenance work to be performed on the ship's ordnance equipment.

TOPIC 3: DOCUMENTATION

You Are Now Going To Learn:

1. The types and uses of naval publications.
2. Classification and safeguarding of naval publications.

Discussion Points For This Topic Are:

1. Sources of publications.
2. Types of publications:
   a. Technical.
   b. Training.
3. Classification of publications.
4. Handling, stowage, and disposal of classified publications.
5. Review and summary.

INFORMATION AND DISCUSSION:

It is a well-known fact that education does not end when you finish school; continual education is important to your naval career as well as to other aspects of your life. When you are aboard ship, you must continue your professional education on your own time either by personal study or by taking correspondence courses.

The information provided in this Trainee's Guide by no means extends to the limits of what you are supposed to know. The competence of a gunner's mate depends not only on his knowledge, but also on his ability to quickly find a reliable source for other necessary information; therefore, a gunner's mate should be familiar with various publications issued by the Navy. Most of them come in series (or groups) and are identified either by serial or code numbers. A common problem is the identification and procurement of publications that are not immediately available aboard ship or at the station.

The main types of Navy publications which a gunner's mate must use aboard ship in connection with ordnance and gunnery equipment are technical and training publications.

Technical Publications

Most of the technical publications are issued by the Bureau of Weapons (BuWeps) and will be discussed in the following text.

Ordnance Pamphlets (OP's):

Ordnance Pamphlets are technical manuals. There are two types of OP's. Most of the OP's are of that type which describes a specific ordnance equipment, its operation, maintenance, installation, and repair. The other type of OP's describes an ordnance subject in general (for instance, battery alignment or ammunition).

All OP's (unclassified and confidential), as well as many other BuWeps technical publications, are indexed in OP 0. (Ordnance technical publications with a higher security classification are indexed in RPS 6.)

OP's are numbered consecutively, without coding.

Ordnance Data (OD):

OD's contain a wide variety of technical information, including test and inspection instructions, advanced information on or advanced instructions for ordnance equipment, lists of ordnance equipment for specific types of ships, etc. OD's are numbered serially and are indexed in OP 0.

Ordnance Alterations (OrdAlts):

Ordnance Alterations contain authorized changes applicable to ordnance equipment which do not modify the military characteristics of a ship. (Alterations of ordnance equipment that modify the military characteristics of a ship are authorized by the Chief of Naval Operations and issued by BuWeps as NavAlts.)

Alterations of ordnance equipment can be authorized only by OrdAlts. The alterations must adhere strictly to the drawings and instructions provided by the OrdAlts. When the changes are completed, they must be recorded in the maintenance records of the gunnery department and must be reported to BuWeps. OrdAlts are listed in a special index, OrdAlt 00.

Ordnance Instructions and Ordnance Notices:

Ordnance Instructions and Ordnance Notices are BuWeps-issued directives and informational copies. They are numbered according to a decimal system established by the Executive Office of the Secretary of the Navy. The issues are numbered in a special way according to their classification by subjects (for instance, administration, supply, procurement, production, fiscal matters, etc.). All issues are indexed in NavOrd Note 5215.

Ordnance Allowance Lists (NavOrd Lists):

Ordnance Allowance Lists are looseleaf lists of required equipment, ammunition, tools, accessories, etc., for ordnance installations afloat or ashore. Revisions and amendments to these lists are made by issuance of new pages to be substituted for the old ones.

NavOrd Lists are indexed in NavSandA Publication 2002, Section XI. This publication supersedes

NavOrd Lists 0 and 00.

NOTE: Ordnance Allowance Lists (NavOrd Lists) should not be confused with Ordnance Equipment Lists which are issued as OD's. Ordnance Equipment Lists are designed for certain classes or groups of ships and are mainly intended to serve as guides for shipyards and shipbuilders.

Coordinated Shipboard Allowance List (COSAL):

COSAL is a single allowance list for each ship with all material (ordnance, electronics, etc.) listed in the same manner. Ordnance material is listed in Chapter 4 which is assembled in a separate binder. In time COSAL may replace NavOrd Lists.

Bulletin of Ordnance Information:

The Bulletin of Ordnance Information is a classified quarterly publication which contains articles about new developments in naval ordnance, equipment under development or in the fleet, new modifications to ordnance equipment, new safety information, and other current data. It also lists all publications issued after printing of the latest OP 0.

NavShips Technical Manuals and Instruction Books:

Personnel of the gunnery department use and maintain a considerable amount of equipment which is under the cogizance of BuShips, such as dredger hoists and missile checkout and handling devices. The technical manuals and instruction books describing this equipment are listed as NavShips publications and are only indexed in and ordered from NavSandA Publication 2002, Section VI, Parts D and E. For example: The technical manual on the electrohydraulic equipment for the CLG-missile (Terrier) handling system is NavShips 378-0258. The second and third numbers (78) indicate which section of BuShips Technical Manual (NavShips 250-000) is applicable to the equipment. Chapter 78, NavShips 250-000, is titled "Ammunition Handling and Stowage."

NavSandA 2002, Navy Stock List of Forms & Publications:

NavSandA 2002 is published by the Bureau of Supply and Accounts. It indexes and provides stock numbers of forms and publications for each bureau of the Navy.

BuWeps forms and publications are listed in Section VIII.

Graphic laminated placards of operating instructions and safety precautions for ordnance equipment are also listed in NavSandA and can be found in Section XIII.

Training Publications

The Bureau of Naval Personnel (BuPers) is basically responsible for all Navy training, except for aviation, medical, dental, joint team and group combat training, and training in certain fleet schools.

The text materials, designed specifically for training Navy personnel and intended for navywide distribution, are issued by BuPers. The materials published by BuPers are used for the following purposes:

1. Navy training courses (Bluebooks) for enlisted personnel intended for their preparation for advancement to specific ratings and grades. (Some of these courses include common subjects like electricity, mathematics, etc.)
2. Navy courses for officers which cover subjects of interest to officers (naval ordnance, gunnery, electronics for guided missiles, etc.).
3. Correxpondence courses on specific subjects for enlisted personnel and officers. These courses are based, respectively, on the texts mentioned in Points 1. and 2. Officer correspondence courses are also available to enlisted personnel on active duty, and the successful completion of these courses is recorded in their Service Record. Correspondence courses are administered by the U. S. Naval Correspondence Course Center, Scotia, New York, and are indexed in NavPers 10052.
4. Instructor's guides and trainee's guides for use in schools controlled by the Bureau of Naval Personnel.

BuPers also issues special-purpose publications, one of which is the periodically issued List of Training Manuals and Correspondence Courses, NavPers 10061 (number is followed by a letter indicating the revision). This publication serves as a catalog of NavPers publications. (All NavPers publications are identified by five-digit numbers.)

Classified Publications

Ordnance publications may be classified as TOP SECRET, SECRET, CONFIDENTIAL, or may be unclassified. Ordnance publications are classified by BuWeps. The Chief of Naval Operations is charged with the responsibility of classification of all material according to its content.

For security reasons, all classified publications are assigned registration numbers. It is required that classified publications be accounted for, including receipt and ultimate disposition.

Everyone is responsible for maintaining the inviolability of classified matter. Classified material is to be handled and stored in accordance with the current edition of the Navy Security Manual for Classified Information, OPNAV Instruction 5510.1.

Confidential publications must be stored in a fireproof safe locked with a triple-combination lock. One man is designated (by official letter) as publication custodian and is made responsible for the publications within the safe. When a classified publication is issued to someone, the person receiving the publication must sign a custody card which is kept by the publication custodian.

Publications classified CONFIDENTIAL (Modified Handling Authorized) may be used in classrooms. When not in use, they may be kept in a cabinet in a locked room, provided that a sentry on watch is in the building at all times.

When an order is given to destroy TOP SECRET, SECRET, or CONFIDENTIAL material, it must be burned, shredded, or pulped. The directing authority normally requires that a certificate of destruction be signed and returned to the directing authority.

TOPIC 4: GENERAL SAFETY PRECAUTIONS

You Are Now Going To Learn:

1. The purpose of safety precautions.

Discussion Points For This Topic Are:

1. Requirement for prevention of accidents.
2. Necessity of safety precautions.
3. Results of carelessness.
4. Review and summary.
5. Section review.
6. Written test.

ASSIGNMENT:

A. Reference publications:

   1. Optional reading list:

      a. OPNAV 34 P1.
      b. OP 1014.
      c. NavOrd Instruction 5100.1.

INFORMATION AND DISCUSSION:

Safety is everybody's job. Awareness of danger, knowledge of how to avoid it, and constant vigilance are the three basic requirements for the prevention of accidents while you are working on or near weapon equipment.

There is more truth than fiction in the adage "Safety precautions are written in blood." It is a fact that safety precautions are mainly derived from costly experiences: Some of the most serious casualties in naval history are attributed to neglect or violation of safety rules in effect or to carelessness and lack of common sense to take precautions which at that time had not yet been written. It is also an established fact that familiarity breeds carelessness.

Safety is both a result and a reflection of good training. The crews of guns or missile launching systems may be trained so that every man thoroughly knows how to do his job; however, the crew still cannot be considered well trained unless every man is safety conscious. Safe working habits must be impressed upon every crewman through proper instructions, constant drills, and continuous supervision.

Carelessness, cockiness, and lack of training have led to disaster while working with all types of ordnance equipment and material. Turrets have exploded; mounts have fired into other mounts of the same ship; ammunition ships were blown up; rockets have burned men to death.

The list of casualties is long. For instance, on October 1, 1951, a 5-inch, 38-caliber gun aboard a destroyer fired into another mount. As a result, six men were killed and fifteen were injured. In the following investigation, the commanding officer and gunnery officer stated that they were unaware that such an accident could be possible: If they had known that one gun could fire into the barrel of another gun, they would have (in compliance with general safety rules) issued additional precautions to prevent such accidents. However, no warning or precautions concerning this hazard had been posted.

The mount captain had not adequately followed the safety requirements: He did not use his sightport to observe the line of fire, to make sure that it was safe to fire. The gun of the mount that was hit (mount 2) was trained and elevated to the "Ready" position, and its barrel was in the line of fire of the firing mount (mount 1). Mount 2 was not firing and was not to fire until after mount 1 had completed its firing. To ensure safe operation, mount 2 should have been held ready at its normally secured position, at zero degrees of train. If this had been done, the accident would not have occurred.

There is a cutout cam installed to prevent guns from firing into fixed objects of own ship's structure which include turrets, mounts, launcher, torpedo tubes, and cranes (in their stowed positions only). The personnel must constantly watch out that these objects do not interfere with the line of fire. In the incident mentioned before, one of the several persons in charge -- the commanding officer, the gunnery officer, the control officer, the mount captain, or one of the safety observers -- could have prevented the accident, since no mechanical defects existed; the failure was due to human carelessness only. The result:

DEAD: 6

INJURED: 15

Another example: In May 1949, aboard a destroyer a gunner's mate was cleaning and chipping paint off a 40-millimeter gun mount. For some reason, against all existing orders, he removed the cover plate from the train-motor control switchbox (perhaps he intended to clean it). Minutes later he was found dead on the deck: He had been electrocuted by a 440-volt circuit. This accident would not have occured if the gunner's mate had observed the following safety rules:

> "When work is done on any circuit, the switch controlling that circuit should be opened and a danger sign secured to it.
>
> "The danger sign should contain sufficient instructions to prevent anyone but the proper individual from energizing the circuit.

> "Each piece of ordnance equipment has a specific list of safety precautions to be observed during operation and/or maintenance. Study these thoroughly before attempting to operate or repair any piece of equipment with which you are not familiar . . . "

Normally, safety rules are considered by all hands as the primary laws of selfpreservation, and therefore willful violations are not common; it is usually the ignorance of their existance and application or a lack of observation, due to overconfidence, that cause the violations.

It is an unquestionable fact that casualties can be prevented by a thorough knowledge and sensible observance of safety precautions. Constant vigilance must be exercised to ensure that every detail of the safety rules is followed. Any violations or tendencies to veer from the prescribed course of safe actions must be stopped at once.

Since no human being is perfect, accidents cannot be outlawed or ordered out of existence; however, a large percentage of casualties can be eliminated by proper overhaul of equipment, inspection and test of material, and by adequate training of personnel in proper handling of their gear. (A detailed list of safety precautions is provided in the optional reading list for this topic.)

QUIZ SHEETS:

1. Which one of the following ordnance items is not classified as explosive ordnance?

   a. Torpedoes.
   b. Missiles.
   c. Guns.
   d. Mines.

2. All ordnance publications are classified by BuPers as Top Secret, Secret, Confidential, and Unclassified.

   True ______ or False ________.

3. Technical manuals for ordnance equipment under cognizance of BuShips are issued by

   a. BuWeps.
   b. BuShips.
   c. BuPers.
   d. CNO.

4. Guns whose caliber is 6 inches or larger are called major caliber guns.

   True ______ or False ________.

5. The gun mechanism that closes the powder chamber of a gun is called

   a. Tompion.
   b. Muzzle disk.
   c. Breechblock
   d. Salvo latch.

6. Blank gun ammunition may include a primer, propellant, and projectile.

   True _______ or False _______.

7. The shattering effect of high explosives is called

   a. Blasting.
   b. Brisance.
   c. Combustion.
   d. Demolition.

8. Which device is used to lock the breechblock in closed position to prevent accidental opening of the breech when a misfire or hangfire occurs?

   a. Safety latch.
   b. Gear latch.
   c. Lock latch.
   d. Salvo latch.

9. Ordnance technical publications with a high security classification are indexed in one of the following publications:

   a. RPS6.
   b. OP 0.
   c. NavOrd List 0.
   d. OrdAlt 00.

10. Training manuals and correspondence courses, issued by BuPers, are listed in NavPers 10061.

    True ______ or False _______.

11. List the three basic requirements for prevention of accidents:

a. ______________________________
____
b. ______________________________
____
c. ______________________________
____

12. Ballistics is the science of projectiles in motion.

True ______ or False ______.

13. Safety precautions are based mainly on costly experiences.

True ______ or False ______.

14. The F-Division personnel man the

a. Launcher.
b. Guns.
c. Magazines.
d. Plotting rooms.

15. The title of any naval gun always includes its

a. Mark number.
b. Mod number.
c. Caliber.
d. Assembly number.

16. When new equipment is installed aboard ship, its name plate should be removed and stowed in a safe place.

True ______ or False ______.

17. List the three main kinds of shipboard maintenance work:

a. ______________________________
b. ______________________________
c. ______________________________

18. A battery log is kept for each 40-mm mount.

True ______ or False ______.

19. Authorized alterations to modify the military characteristics of a ship are called

a. NavAlts.
b. ShipAlts.
c. OrdAlts.
d. MajorAlts.

20. The leading gunner's mate is responsible for keeping the machinery history records up-to-date.

True ______ or False ______.

21. Replacement parts are ordered by using Federal stock numbers.

True ______ or False ______.

Accuracy of notes checked by instructor:

Date ______________________________

Trainee's initials ___________________

Section 3

INTERPRETATION OF SCHEMATICS

ASSIGNMENT-DISCUSSION-PRACTICAL WORK-QUIZ SHEETS

Topic No.	Topic Title	Page
1.	Introduction to Blueprints	58
2.	Drawing Symbols	62
3.	Drawing Views	70
4.	Notes, Specifications, and Dimensioning	76
5.	Ordnance Drawings	84

TOPIC 1: INTRODUCTION TO BLUEPRINTS

You Are Now Going To Learn:

1. The definitions, types, and uses of blueprints.

Discussion Points For This Topic Are:

1. Definition of blueprints.
2. How prints are made.
3. Types of prints and their uses.
4. Technical sketches.
5. Handling and care of prints.
6. Review and summary.

ASSIGNMENT:

A. Reference publication:

   1. Study NavPers 10077-A, Chapters 1 and 6.

INFORMATION AND DISCUSSION:

Blueprints are exact copies of mechanical or other types of drawings. The process for making blueprints is similar to the photographic process for making prints from negatives.

The negative for a blueprint is called a tracing. The tracing is made by placing a sheet of translucent (tracing) paper or cloth over an original drawing. Every detail of the drawing is then copied on the tracing paper or cloth with waterproof black (India) ink or a special black pencil.

A new process of reproducing original drawings is called photo-tracing. This process is faster and requires less skilled draftsmen than handtracing, but reproduction costs are higher than in the old process.

In the photo-tracing process, the pencil drawing is considered to be the master (original) until a photo-tracing has been made; thereafter the photo-tracing becomes the master. All additional photo-tracings of the same master are called copies. Prints made from the master can be reproduced in various sizes. Several reproduction processes can be used.

The following is a list of prints which are all reproductions of originals, but are separately classified, because they are reproduced by various processes.

1. Blueprints are the oldest and most common-type prints. They have a blue background with white lettering. Blueprints are valuable long-lasting records and, with proper handling, can be used again and again. Blueprints should be protected as much as possible against the sun because they tend to fade

when they are exposed to direct sunlight.

2. Vandykes have a brown background with white lettering. Vandykes differ from blueprints in that they can be used as negatives for duplication. Since the paper of vandykes is thin, they are not as durable as blueprints.

3. Black-and-white prints have a white background with dark lettering. They are easier to read than blueprints and for this reason are better than blueprints when used as training aids.

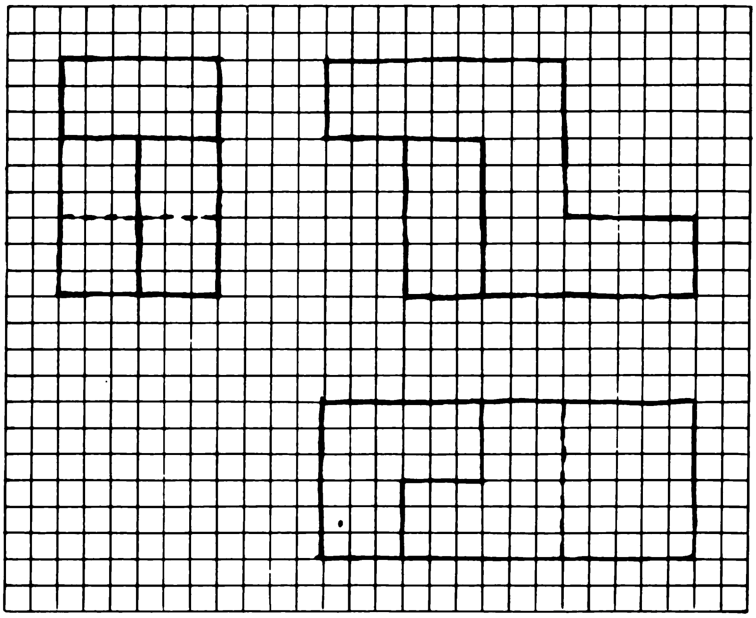
4. Ozalid prints are similar to black-and-white prints, except that due to the ozalid reproduction process they are not long-lasting.

5. Photoprints are normally 14 x 17 inch prints with white lettering on blue background. Photoprints are standard record-prints of drawings furnished to all ships. Photoprints can be obtained on special order with black lettering and white background.

Technical or Working Sketches:

Technical or working sketches are often used to show complete assemblies or their separate parts. These sketches can also be made free-hand.

A gunner's mate must be skilled not only in interpreting technical sketches, but also in making them, since many job orders sent to tenders and Navy yards must be

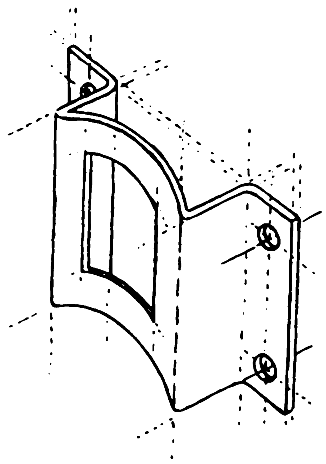


3-1. WORKING SKETCH ON CROSS-SECTION PAPER accompanied by sketches of certain items.

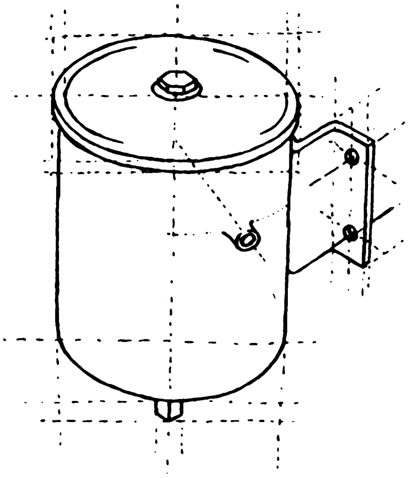
The technical or working sketches should contain the information required for serving the specific purpose; however, the dimensions and notes that appear on the sketches should conform with standards.

There are four types of sketches:

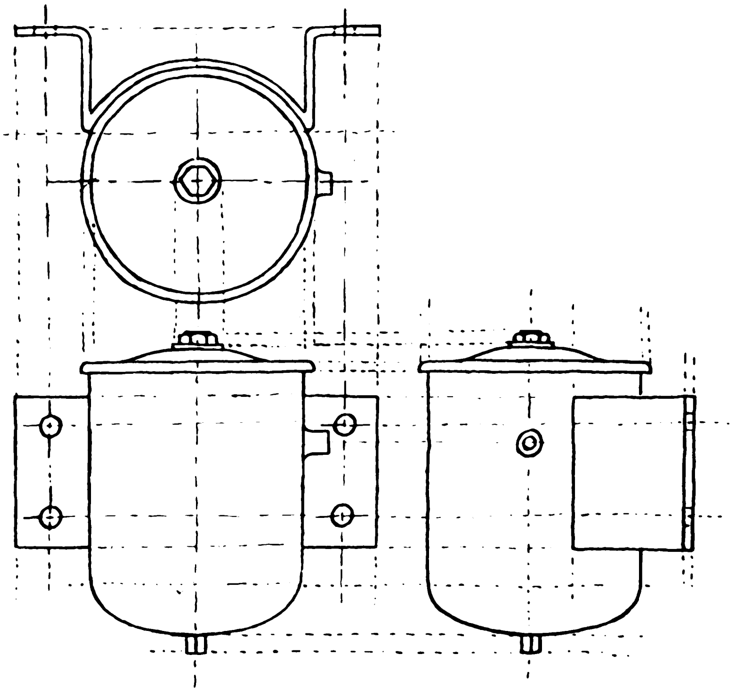
1. Perspective assembly.
2. Perspective detail.
3. Orthographic assembly.
4. Orthographic detail.



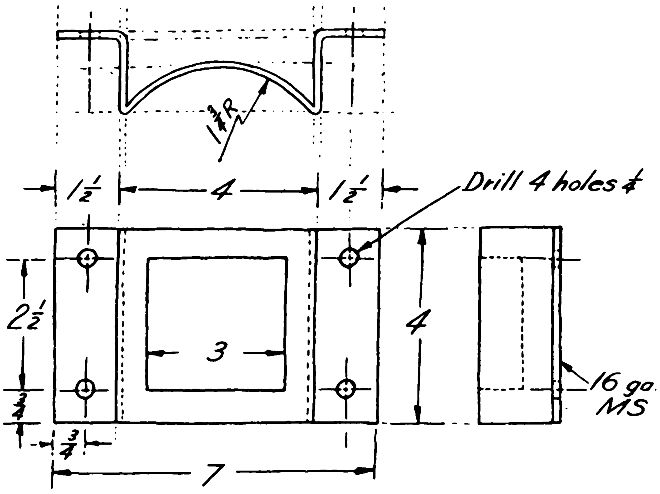
3-3. PERSPECTIVE DETAIL SKETCH OF OIL FILTER BRACKET



3-2. PERSPECTIVE ASSEMBLY SKETCH OF AN OIL FILTER



3-4. ORTHOGRAPHIC ASSEMBLY SKETCH OF AN OIL FILTER



3-5. ORTHOGRAPHIC DETAIL SKETCH OF OIL FILTER BRACKET

Handling and Care of Prints:

All prints should be filed numerically and stowed for ready reference. However, security regulations require that classified prints be filed separately in locked cabinets.

All prints should be kept free from oil and grease. Prints should be neatly folded in such a way that the title-block be visible. Large prints should always be folded in an accordion-like manner. This kind of folding is made by starting at the title-block end and by alternately folding the print back-to-back and face-to-face.

TOPIC 2: DRAWING SYMBOLS

You Are Now Going To Learn:

1. Types and purpose of drafting symbols.

Discussion Points For This Topic Are:

1. Identification and use of material symbols.
2. Introduction to special symbols.
3. Types and uses of line symbols.
4. Types and uses of thread symbols.
5. Classification and definitions of threads.
6. Review and summary.

ASSIGNMENT:

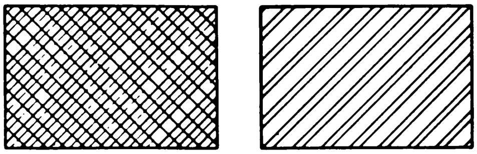
A. Reference publication:

   1. Study NavPers 10077-A, Chapter 3.

INFORMATION AND DISCUSSION:

In the preparation of drawings, standard drafting symbols are used. Some of these symbols will be discussed in this topic; the symbols used in hydraulic and electrical drawings will be discussed in Sections 7 and 10, respectively.

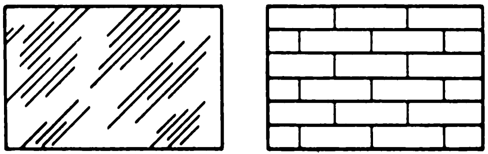
Military standards include symbols of various materials and thus define the texture of materials. The following illustration shows several types of drafting conventions of various materials.



Tin

Steel and wrought iron

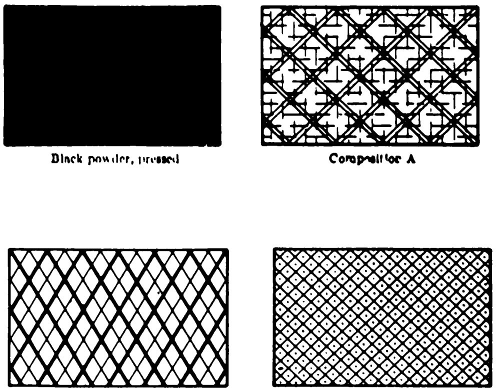
Sectioning conventions



Glass and transparent material

Brick

Exterior conventions



Black powder, pressed

Composition A

Explosive D

Inert filler

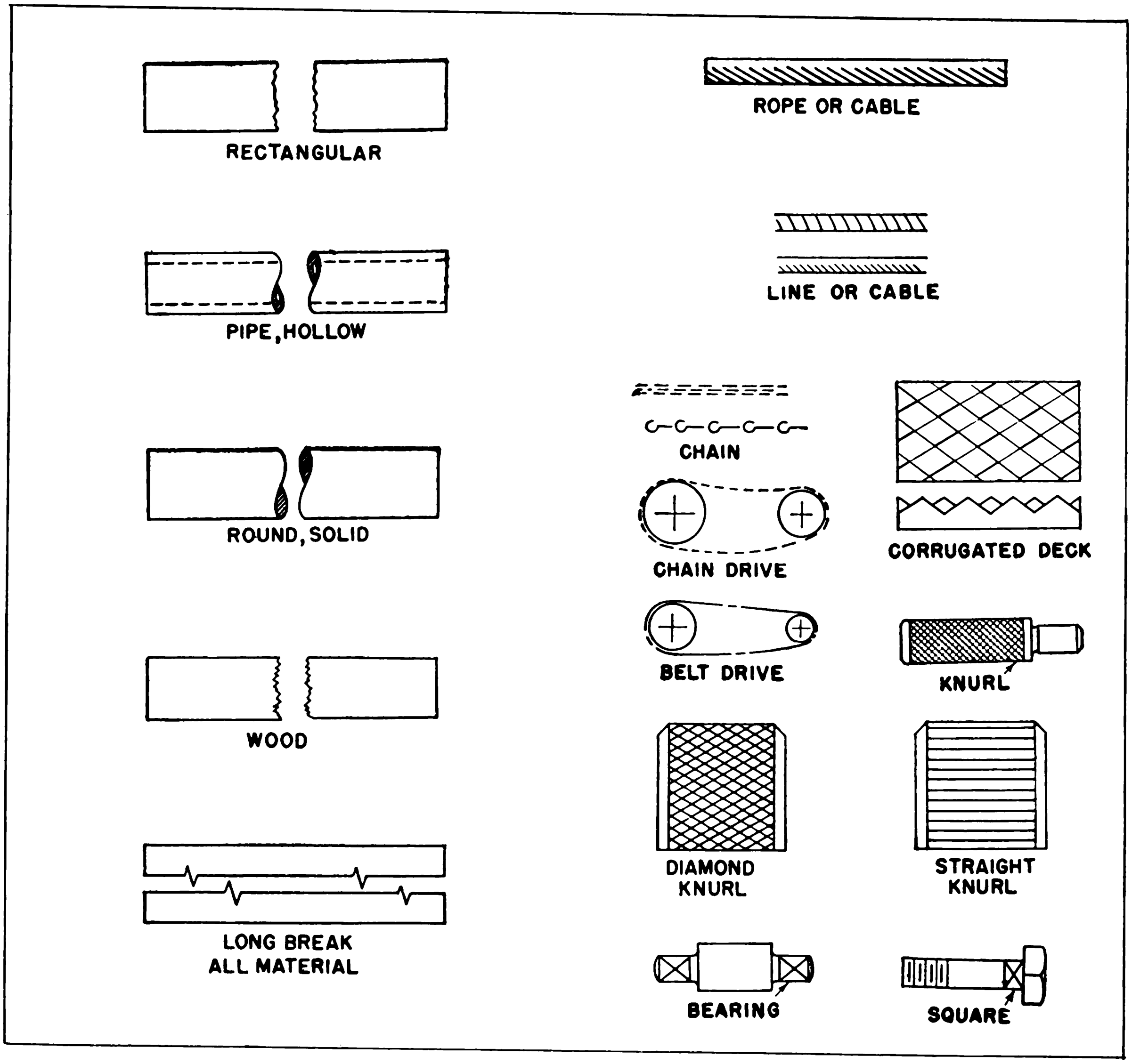
Special conventions

3-6. DRAFTING CONVENTIONS

These material symbols, however, do not include specific classifications of materials; for example, wrought iron, stainless steel, and tungsten steel would all be shown by the same symbol. The specific type of material used is specified elsewhere on the blueprint.

On nonstandard prints, special symbols or colors may be used. These symbols or colors are always explained in the legend of the print.

The following illustration shows some typical examples of special drafting symbols.



3-7. CONVENTIONAL BREAKS AND SPECIAL SYMBOLS

When preparing drawings, a draftsman frequently must present a great deal of information within a limited space. Instead of using words or lengthy written explanations, he uses standardized lines which have various widths and other special characteristics. All these types of lines have their special meanings. To interpret and to understand a drawing or a blueprint, you must know what the various lines mean.

An outline is a heavy solid line which represents the edges and surfaces visible from the point from which the object is drawn.

3-8. OUTLINE

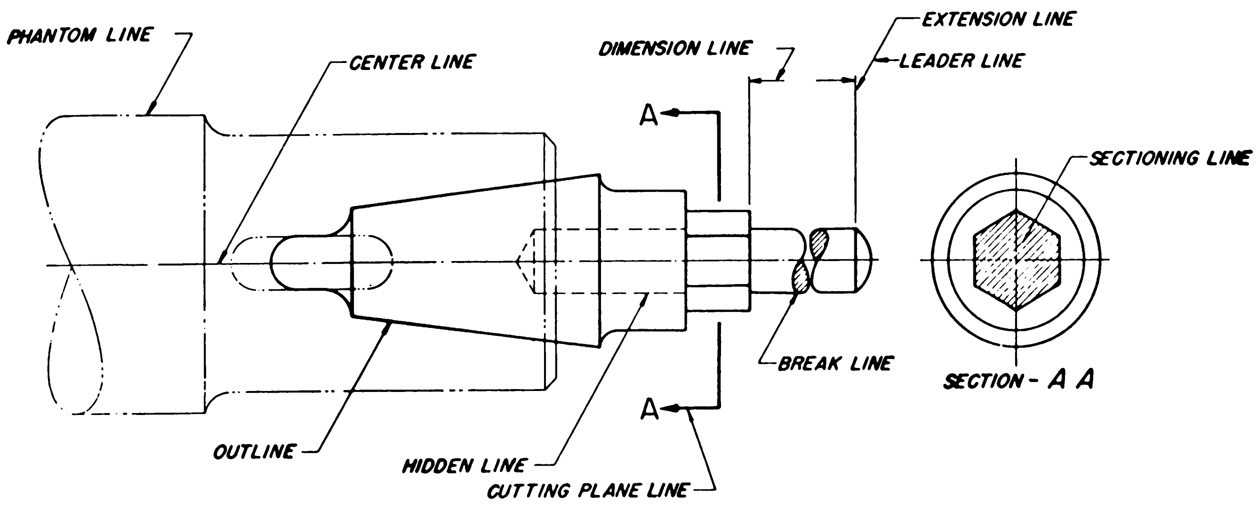
A hidden line is a light line which consists of dashes and represents an edge or a surface which cannot be seen from the point from which the object is drawn.

3-9. HIDDEN LINE

The outlines and hidden lines constitute the backbone of a drawing.

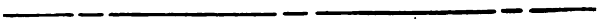
NOTE: For a combination of the various types of lines used, refer to illustration #3-10.

A phantom line consists of light long and short dashes which alternate according to an established pattern: one long dash and two short dashes. Phantom lines are used to indicate hidden parts and the alternate positions of moving parts. (Refer to illustration below.)



3-10. VARIOUS TYPES OF LINES

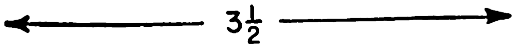
A centerline consists of light alternating long and short dashes. Centerlines are used to indicate the center of a circle or an arc and to show the division into equal parts of the object on the drawing.



3-11. CENTERLINE

Dimension lines are used to indicate the size of the object shown on the drawing. Generally, Navy blueprints are dimensioned in inches.

The preferred way of indicating dimensions is shown in illustration #3-12. The measurement given shows the distance between the points of the arrowheads. Other ways of indicating dimensions are shown in illustration #3-35 on page 82.



3-12. DIMENSION LINE

It is preferred that dimensions be placed outside the view of the object, because dimensions placed inside the outline of the drawing interfere with the view of the object.

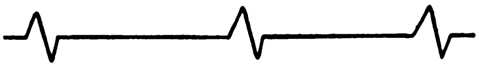
Extension lines are light lines which extend from the lines of the outline of the object. (Refer to illustration #3-10 on preceding page.) Extension lines are used for placing the dimension lines outside the view of the object. They usually start about one-sixteenth of an inch from the outline of the object.

Refer to illustration #3-10 and note how the various lines are labelled. Each line-designation is tied to the corresponding line of the drawing by a leader. For exact indication of dimensions and dimensional or other explanatory notes, only leaders consisting of straight ruled lines should be used. The note-end of the leader should always point either to the beginning or to the end of the dimension or note (never to the middle). In general, dimensional leaders should point only to that part of the drawing which shows the profile (outline) of the object.

Drawings usually have a better appearance when the adjacent leaders are parallel; however, leaders should never be parallel to adjacent dimension lines or extension lines. On drawings which contain symmetrical features, the leaders should point to the center of the feature. The arrowhead of a leader should end exactly on the line which represents the profile of the object.

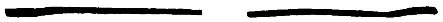
Since most drawings are limited to a certain size, the draftsman must frequently reduce large objects which would take up more space than permitted. However, to avoid undersizing, a draftsman may use long-break lines, to indicate that he has shortened a part on the drawing.

NOTE: The long-break line, which is used only as a space saver, does not change the actual dimensions of the object.



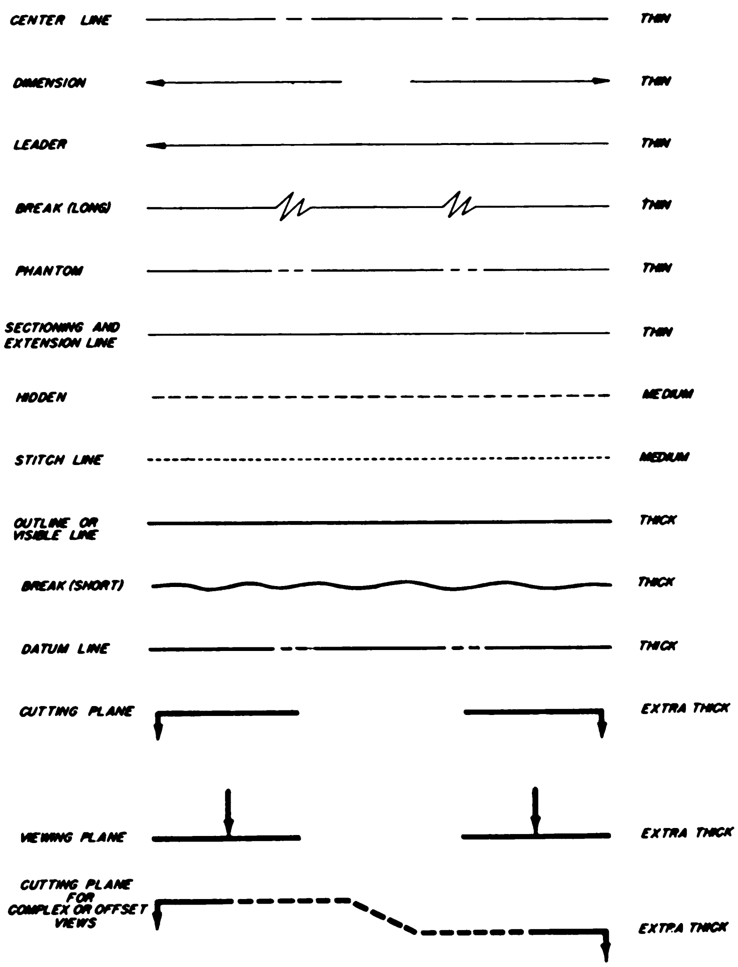
3-13. LONG BREAK LINE

Short-break lines are used to indicate that the draftsman has intentionally omitted a part of an outer surface in order to show the inside of the structure. Short break lines are generally used in pairs.



3-14. SHORT BREAK LINE

NOTE: The various types of lines used on drawings are shown on illustration #3-15. Carefully study the designations of these lines and learn to distinguish them by their widths and other characteristics.



3-15. LINE CHARACTERISTICS AND CONVENTIONS

On ordnance drawings, threads may be represented in various ways. Refer to illustration #3-16 and note that on the right part of the drawing, a common method of showing threads is used. The left part of the drawing presents the end-view of a threaded shaft or bolt. The center part of the drawing presents the profile and sectional view of a thread.

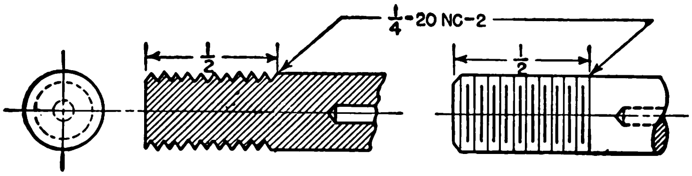
To save time, the draftsman used the standard symbol for representing a thread. The dimension of the threaded part is indicated left above (1/2 inch). Additional information is given in the note (1/4-20-NC-2). The first number of this note indicates the outside diameter of the thread (1/4 inch); the second number indicates how many threads there are per inch (20); the letters NC indicate the thread series (National Coarse); the last number indicates the class and tolerance (fit) of the thread (2 indicates free fit).

Specifications for manufacturing screws must include diameter, series, class of fit, and number of threads per inch.

There are several types of pitch series of threads which include:

1. National Coarse (NC).

2. National Fine (NF).



3-16. OUTSIDE THREADS

3. National Standard (NS).

4. Pipe.

National Standard and National Fine are the most commonly used types of threads.

According to their fits, threads are classified as follows:

Class 1: Are not used on ordnance equipment. They are generally used on equipment where loose fit is not objectionable.

Class 2: Most widely used on general (not precision) equipment.

Class 3: Used only for precision tools and precision equipment (high-grade threads).

Class 4: Are hand-selected for best fit (precision threads).

The following are definitions of some common terms used in connection with threads:

1. The pitch is the distance between two corresponding points on two adjacent threads, measured parallel to the axis.

2. The lead is the distance which a screw advances in one turn.

3. The major diameter of a thread is its largest diameter.

4. The minor diameter of a thread is its smallest diameter.

5. The crest is the top of the thread which represents the major diameter of the threaded part of a screw and the minor diameter of a nut.

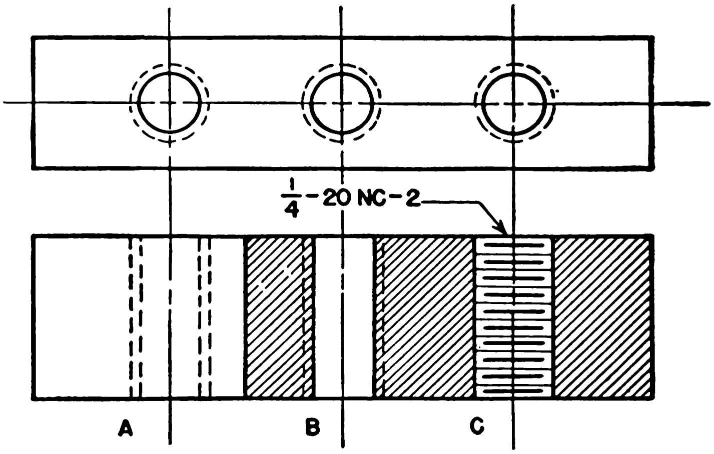
6. The pitch diameter is the diameter of the threaded part of a screw which is cut by the surface of an imaginary cylinder at certain points, in order to equalize the width of the threads and the width of the spaces between the threads.

7. The root of a thread is the bottom surface of a thread which joins its adjacent sides.

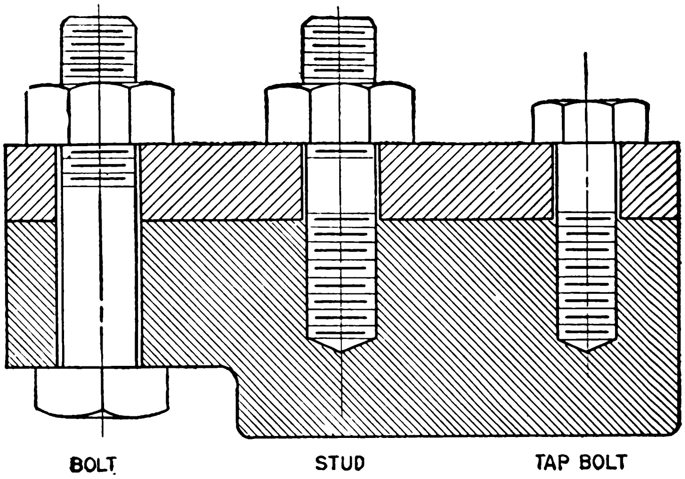
8. The depth of a thread is the vertical distance measured from the crest of a thread to its root.

To draw internal threads, several kinds of symbols may be used. An example of internal-thread symbols is shown in illustration #3-17.

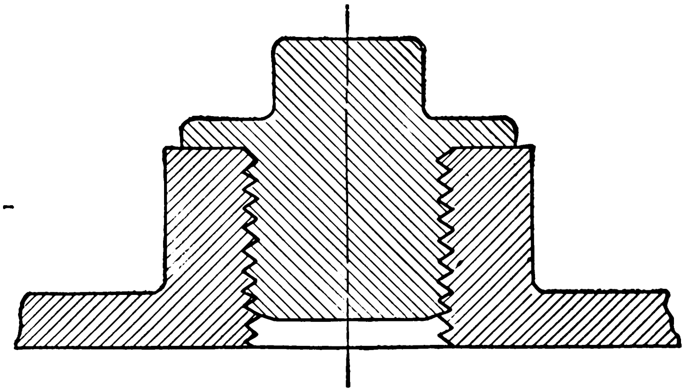
Bolts and studs may also be represented on drawings by outlines and symbols. (Refer to illustrations #3-18 and #3-19.)



3-17. INTERNAL THREADS



3-18. BOLTS AND STUDS



3-19. BOLT, CROSS-SECTION

TOPIC 3: DRAWING VIEWS

You Are Now Going To Learn:

1. Types and purposes of views presented in drawings.

You Will Acquire Skill In:

1. Drawing isometric, orthographic, and sectional views.

Discussion Points For This Topic Are:

1. Definition and use of perspective views.
2. Definition, use, and dimensioning of isometric views.
3. Definition, use, dimensioning, and interpretation of orthographic views.
4. Definition, types, and uses of sectional views.
5. Review and summary.

ASSIGNMENT:

A. Reference publications:

  1. Study NavPers 10077-A, Chapter 2.
  2. Review NavPers 10077-A, Chapter 3, pages 27 through 33.

INFORMATION AND DISCUSSION:

Drawings are valuable visual aids used for showing complete assemblies or parts, their location, functions, or construction features.

Drawings may also be used as guides for disassembling and assembling complicated mechanisms or for presenting new types of equipment before they are manufactured.

Perspective Drawings:

Perspective drawings are similar to photographs. However, like photographs, they do not show the object in proper proportions. (Refer to illustration #3-20 on the following page.)

Isometric Drawings:

Isometric drawings are similar to perspective drawings, with the exception that the lines which are parallel on the object are also parallel on an isometric drawing. (If extended, parallel lines on an isometric drawing will never meet.)

On an isometric drawing, three views of an object can be shown at once in proper dimensions, although the general appearance of the object is distorted. (Refer to illustration #3-21 on the following page.)

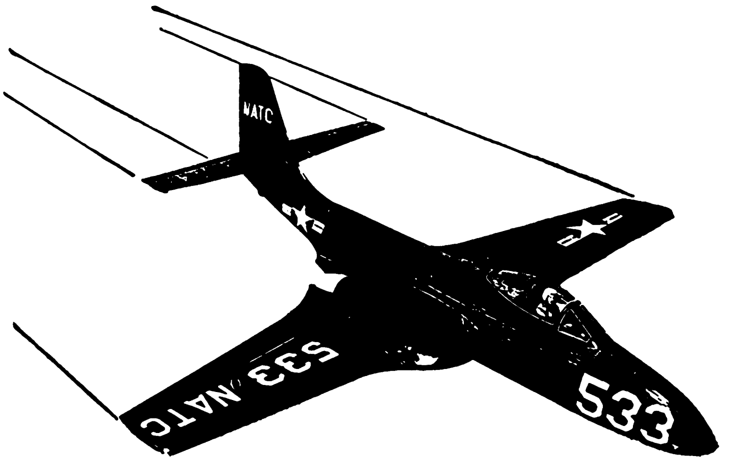
The vertical and horizontal lines of an isometric drawing are called isometric lines. All horizontal and vertical lines on an isometric drawing show the object in proper proportions; the vertical lines of the object are shown vertically, but the horizontal lines are drawn at an angle of 30 degrees with the line of the horizon.

Refer to illustration #3-22 and note that all lines except A and B, have proper proportions because they represent the horizontal and vertical lines of the object. Lines A and B are not isometric lines; therefore their proportions are not correct.

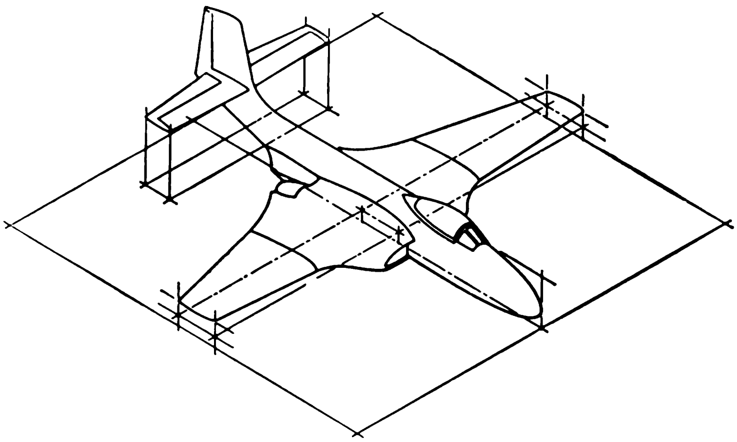
Isometric drawings are used for the same purposes as other drawings. Isometric drawings may also be dimensioned. Blueprints of these dimensioned drawings may be used for representing simple objects. For showing complicated parts or structures, isometric drawings cannot be used alone; they can be used only as aids to supplement orthographic drawings.

Orthographic Drawings:

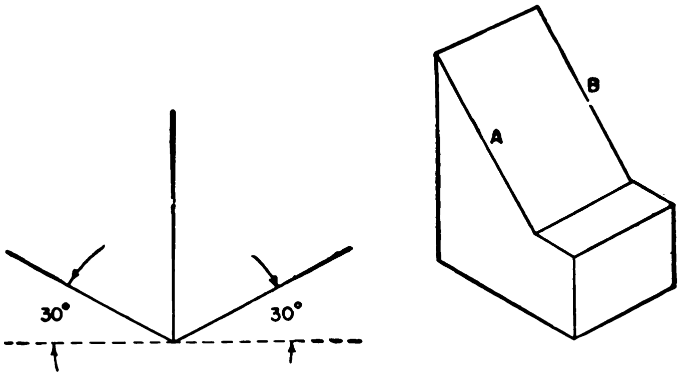
Orthographic drawings are used for furnishing complete information for construction and repair purposes. Since these



3-20. PERSPECTIVE VIEW



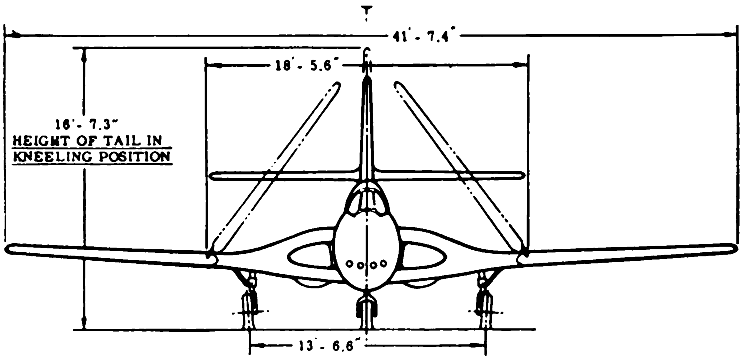
3-21. ISOMETRIC VIEW PRESENTING THREE VIEWS OF OBJECT



ISOMETRIC LINES

ISOMETRIC VIEW

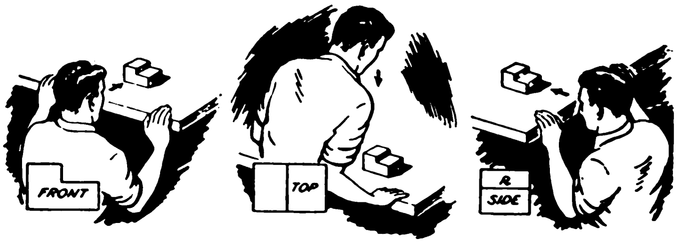
3-22. ISOMETRIC VIEWS PRESENTING PROPORTIONS OF LINES drawings are accurate and represent the objects in their proper dimensions, they are the foundation of all construction blueprints.



3-23. ORTHOGRAPHIC VIEW

NOTE: While studying an orthographic drawing, look only at one surface of the object (top, front, or side) at a time; this will help you to visualize the appearance of the whole object. To determine the correct shape and size of the surface, the line of sight must be perpendicular to all points of that surface.

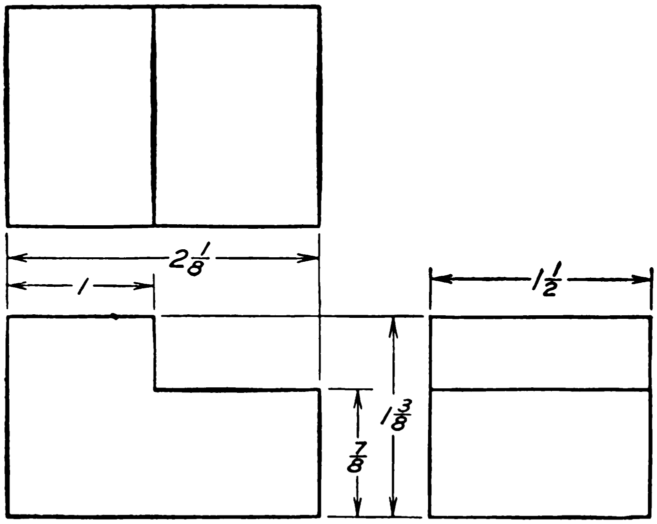
On orthographic drawings, the correct relationship of the various surfaces is maintained by proper arrangement of the views.



3-24. COMPARISON OF ORTHOGRAPHIC VIEW WITH MODEL

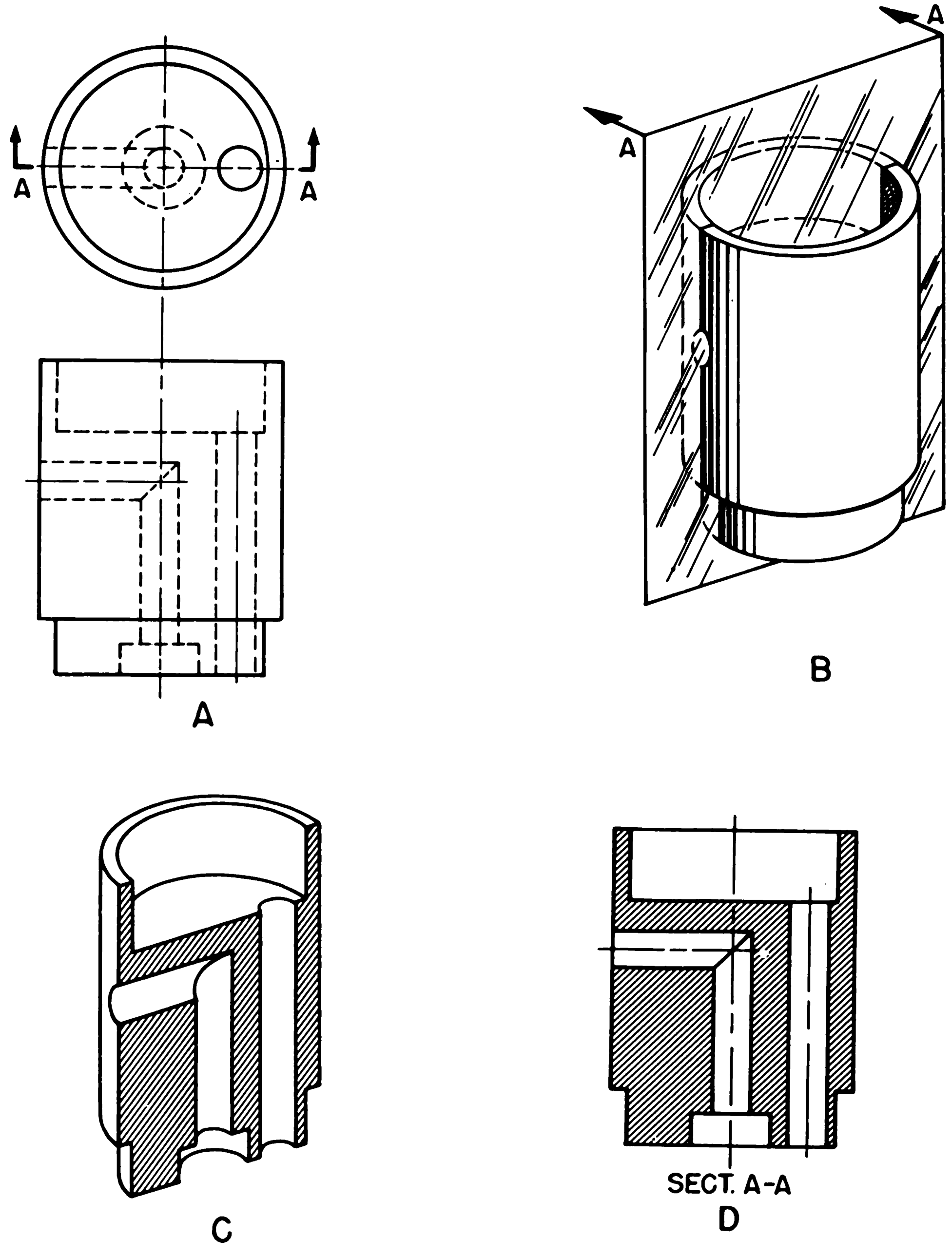
Sectional Drawings:

Sectional drawings reveal the inside of an object just as if it had been cut in half along the cutting plane. These drawings are used to ease understanding of the arrangement of complicated parts.



3-25. DIMENSIONING OF ORTHOGRAPHIC VIEWS

Refer to illustration #3-26, item A, on the following page, and note that the cutting plane line AA shows where the imaginary cut has been made; the isometric view, item B, is presented as an aid for visualizing the cutting plane. In item B, the arrows point in the direction of the sectional view. Item C shows the inside of the object as if it actually were cut in half. Item D presents an orthographic view of the same section as item C.



3-26. SECTIONAL VIEW

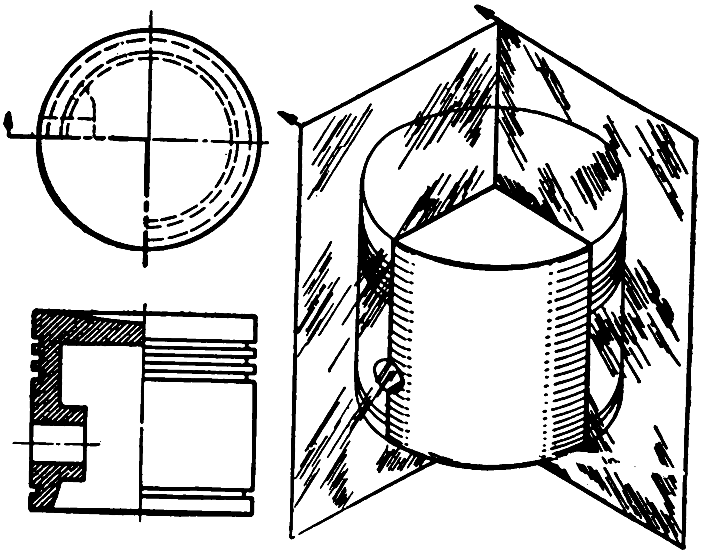
When sectional views are shown on drawings, the part that is cut by the cutting plane is marked by diagonal parallel lines. The draftsman's definition for drawing these lines is "crosshatching". When more than one part is shown on one view, each part which is sectioned is crosshatched with a different slant of lines.

Half-section views are used to present objects which are symmetrical outside and inside.

On half-section views, one half of the object is shown sectioned, and the other half is shown complete. If the object is round, it is cut into two equal parts, and these two halves are again cut in equal halves. One of these quarters is then removed to show the cutting perspective.

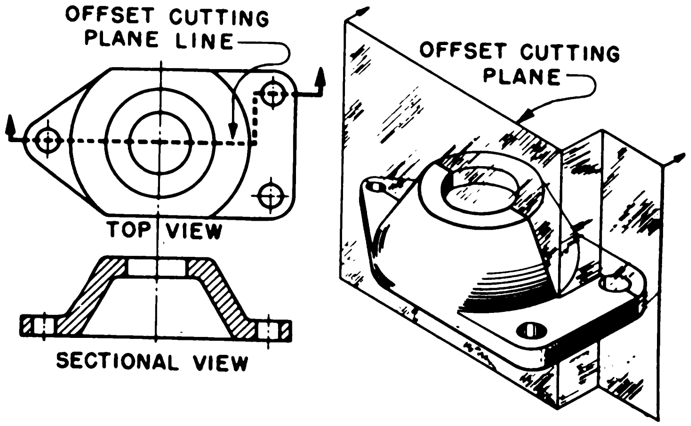
If the cutting plane had extended along the entire diameter of the cylinder, a full section could be shown. In illustration #3-27, the cutting plane extends only half of the diameter; therefore the drawing is called a half-section view.

In the view of an offset section, there is a joggle, or offset, in the cutting plane.

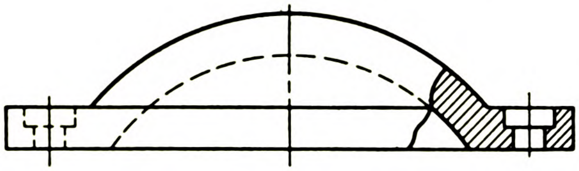


3-27. HALF-SECTION VIEWS

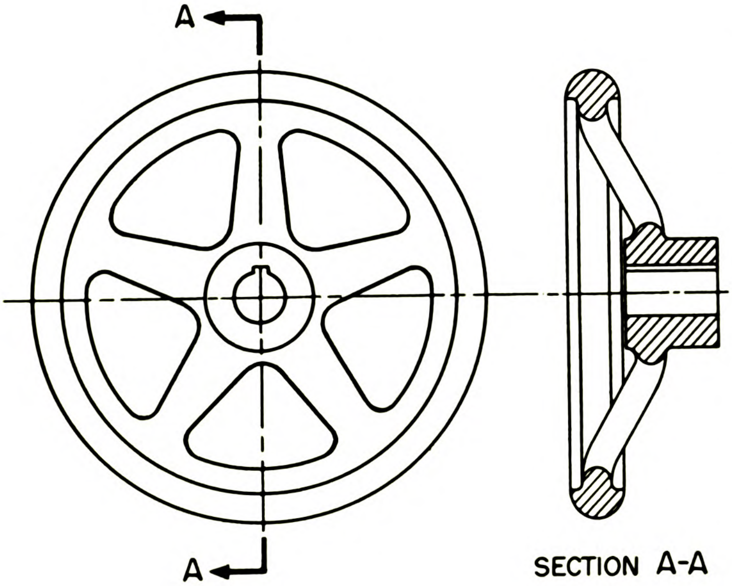
In the top-view of the illustration shown below, the cutting plane is offset to show the hole on the right side of the sectional view.



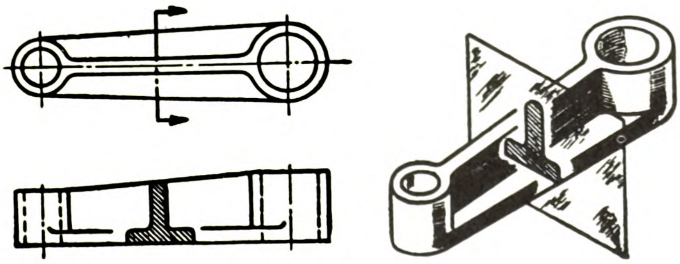
3-28. OFFSET SECTION VIEWS



3-29. BROKEN-OUT SECTION VIEW



3-30. ALIGNED SECTION VIEWS



3-31. REVOLVED SECTION VIEWS

The broken-out section of a small area can be shown by "peeling back" (removing) the outside surface. The broken-out section provides a good view of the inside of the counterbored hole.

Aligned section views are used when other sectional views might be misleading. Parts, like ribs or spokes, are then shown as if they were rotated into or out of the cutting plane.

In illustration #3-30, the spokes in section AA are not sectioned. If the spokes were sectioned, the first impression would be that the wheel consists of a solid web (not of spokes).

To eliminate extra views of rolled shaped ribs, revolved section views are used. These are actually drawings within drawings, but they clearly define the shape of objects at certain cross-sections, stations, or points.

In illustration #3-31, the objects are revolved so that they can be looked at head on. Because of this feature (revolving), the sections are called revolved sections.

TOPIC 4: NOTES, SPECIFICATIONS, AND DIMENSIONING

You Are Now Going To Learn:

1. Location, contents, and purpose of notes and specifications used on drawings.
2. Dimensioning of drawings.

Discussion Points For This Topic Are:

1. Title block, its location and contents.
2. Supplementary block, its location and contents.
3. Application block, its location and contents.
4. Security classification block, its location and contents.
5. Revision block, its location and contents.
6. Special blueprint notes:
   a. Bill of material.
   b. Specifications and standards.
   c. Heat treatment.
   d. Surface finish.
   e. Part identification numbers.
7. Dimensioning.
8. Review and summary.

ASSIGNMENT:

A. Reference publications:

1. Study NavPers 10077-A, Chapters 4 and 5.
2. Study OSTD 599, Sections 6, 7, and 8.

INFORMATION AND DISCUSSION:

In accordance with military standards, the major part of the information and notes applicable to a particular print is located in the lower right-hand corner of the drawing.

Title Block:

The title block is located nearest to the right edge of the drawing and contains the following information:

1. Title (name) of drawing.
2. Drawing number.
3. Name of bureau that authorized drawing.
4. Name of contractor or Navy activity that prepared drawing.
5. Initials of draftsman, initials

of person who checked drawing, and initials of supervisor or senior engineer, with corresponding dates.

6. Authentication and date.
7. Scale of drawing.
8. Unit weight.
9. Code identification number.

All drawings are identified by numbers which appear in the number-block, in the lower right-hand corner of the title block. In addition, drawing numbers may also be shown in other places; for example, near the top border-line, in the upper right-hand corner, or at both ends of the reverse side of a drawing so that the number is visible when the drawing is rolled.

The numbers are used to facilitate identification of drawings. If a blueprint consists of more than one sheet and each sheet has the same drawing number, this information is included in the number-block, indicating the number of the particular sheet and the number of sheets in the series.

BuWeps drawing numbers are assigned to Navy activities and to contractors by the Central Technical Documents Office, U.S. Naval Ordnance Plant, Louisville, Ky.

To become official, all drawings must be authenticated and dated. A drawing is considered to be authenticated if it is signed by the proper authority. Drawings may be signed by commanding officers of Navy activities, or by Navy inspectors at contracting activities, or by persons who have authority delegated by commanding officers or Navy inspectors.

The scale of a drawing is given in the title block. The scale indicates the proportion of the drawing to the actual size of the object shown in the drawing. The proportion is usually stated as 1" = 2", 1" = 12", etc.; or as 1 : 2, 1 : 12, etc.; or as $\frac{1}{2}$, $\frac{1}{12}$, etc.; but may also be indicated as "full size," "one-half size," etc.

Selection of scale depends upon the size of the object to be drawn and the space available on the sheet. To provide a complete view of a large object, the object is shown reduced; to provide a better view of a very small part, the part is shown enlarged.

If the draftsman uses a scale of 1" = 2", the object shown on the drawing is reduced to one-half of its actual size; if the scale is 3" = 1", the object shown is enlarged three times its actual size.

To determine the actual size of an object shown on a drawing, use the dimensions provided. They are correct and always remain the same. Do not measure the drawing, because

1. If the draftsman has made a

mistake in the measurements, you will repeat it.

2. The print might have been reduced (might be smaller than the original drawing), and in the process of reduction, errors could have been introduced.

3. You may forget to consider the scale of the drawing.

4. Paper may stretch or shrink due to humidity changes.

The unit weight is the weight of the item shown on the drawing. The weight is given in pounds.

The code identification number designates the bureau that authorized the print. For instance, BuOrd prints were designated 80066; BuWeps prints are designated 10001.

Supplementary Block:

The supplementary block is located left of the title block and contains the following information:

1. General tolerances applicable to the item shown on the drawing, except the tolerances given in notes on the drawing.

2. Type, class, and grade of material furnished for the end-product.

When the space provided in the supplementary block is insufficient for listing all information, a special note is included within the field of the drawing.

Application Block:

The application block is located next to the supplementary block. The application block contains further identification of the part or the assembly shown on the drawing. This block contains the drawing number of the next higher assembly and the applicable list of drawings (LD).

Security Classification Block:

The security classification block, used only on classified drawings, is located next to the application block. The security classification block indicates the classification of the drawing and contains a warning note. The classification is also repeated several times around the border of the drawing.

Revision Block:

The revision block is always located on the right side of the print, usually in the upper corner. The revision block contains a revision letter, a brief description of the revision, and the date and initials of the person who approved the revision.

Special Blueprint Notes:

Special blueprint notes, which do not require leaders, are located outside of the view of the object, at either end of the drawing. These notes are usually numbered in consecutive order and may be referred to by numbers within the field of the drawing.

The following types of notes are frequently found on drawings:

1. Bill of material.
2. Specifications and standards.
3. Heat treatment.
4. Surface finish.
5. Part identification numbers.

A special box on the drawing may contain a list of stock items required for assembling a unit or a complete assembly. This list is called bill of material and contains a listing of the type, size, and specification of stock.

The bill of material for an assembly drawing frequently also includes a list of standard parts. Many items of common use, such as machine bolts, screws, turnbuckles, rivets, pipe fittings, and valves, have been standardized by the Army, Navy, and Air Force. Each standardized item is listed by a number which is preceded by the letters AN. For example, a wing-nut has an Army-Navy specification number of AN 350; a flathead sheet metal screw is listed as AN 531.

NOTE: Always use the material specified. Never substitute material without proper authorization. The material specified is selected by an engineer because it meets the requirements; it is the best material for that particular job. When the material specified is not available, substitution of material can be authorized only by an engineer or a man who has the authority of an engineer for that particular job.

The Index of Navy Department Specifications, published quarterly by the Bureau of Supplies and Accounts, contains interim bureau specifications and joint Army-Navy, Navy, and Federal specifications used by the Navy.

The specification-notes and standard-notes of a drawing refer only by number to the applicable specifications or standards. To understand the note, it is usually necessary to obtain the particular specification or standard.

Navy Department Specifications are approved by all bureaus concerned and are administered by the Navy Department Specifications Board. The specifications are identified by standard specification numbers of the Navy Department. These numbers consist of the standard stock-class number, the first letter of the material, and a serial number.

Joint Army-Navy Specifications have been developed and adopted for use by the Department of Defense. Material listed according to these specifications is identified JAN or MIL, followed by the first letter of the material and a serial number. (For example: MIL-F-00036 is a type of welding flux.)

Federal Specifications point out the characteristics of materials and supplies used jointly by the Navy Department with other Government agencies. All Federal specifications used by the Navy are listed in the Index of Navy Department Specifications.

General Specifications for Inspection of Material list the requirements which have to be fulfilled by Navy contractors.

The notes or specifications on a blueprint may point out the type of heat treatment the material requires, since practically all metals require heat treatment in the manufacturing process. It is frequently necessary to remove the temper from a piece of metal, so the metal can be machined according to specifications. After this operation, the metal must be rehardened. To determine the type of heat treatment required and at which point of processing the heat should be applied, reference should be made to the specifications in the note.

Finish marks are used to indicate which surfaces must be finished by machining. Machining improves the appearance of a surface and provides a closer fit of the mating parts. During the finishing process, the required limits and tolerances must be observed. (Finishing by machining, however, should not be confused with finishing processes in which paints, enamel, grease, chromium plating, and similar coatings are used.)

An identification number of a part shown on a blueprint is not only an identification number of the part, but is also the identification number of the detail blueprint that shows this part.

Sometimes two parts are shown on one detail print; when this happens, both parts have the same basic number plus individual numbers (such as 34105-1 and 34105-2). These individual numbers are also used to identify right-hand and left-hand parts.

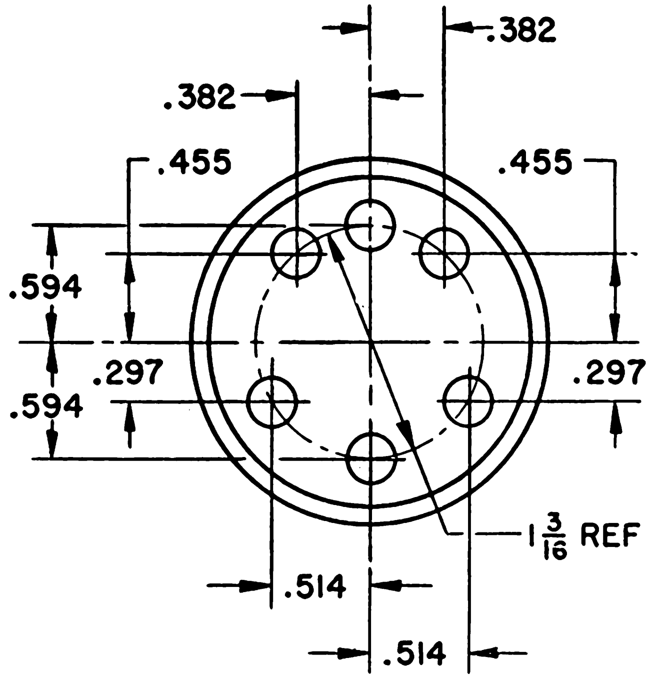
Dimensioning:

Dimensioning is used to determine the size and location of certain components or points of the object shown on a print and to define their particular limits and tolerances. Dimensioning and tolerancing of military prints are performed according to MIL-STD-8A.

The size and location may be determined by either one of the two following methods:

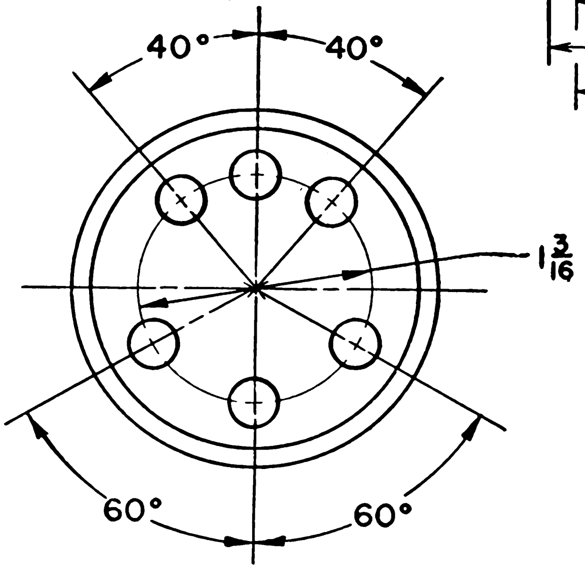
1. Rectangular dimensioning--used to locate points by means

of linear dimensions parallel to reference lines.



3-32. RECTANGULAR DIMENSIONING

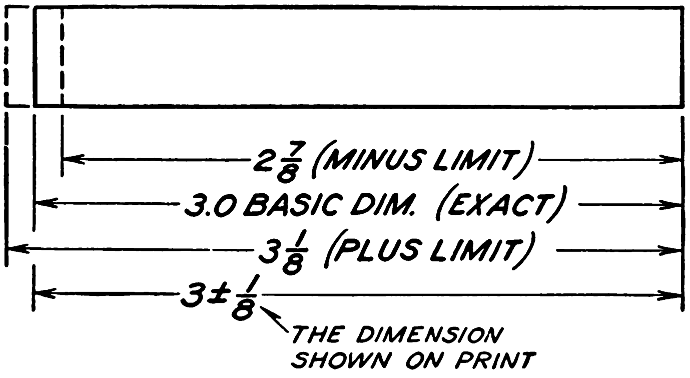
2. Angular dimensioning--used to determine the position of a point, line, or surface by means of angular references.



3-33. ANGULAR DIMENSIONING

Both methods of dimensioning may be used on the same print. However, the same surface or point must be measured by only one method. Wherever tolerances are close (very small), the rectangular method is generally preferred to the angular.

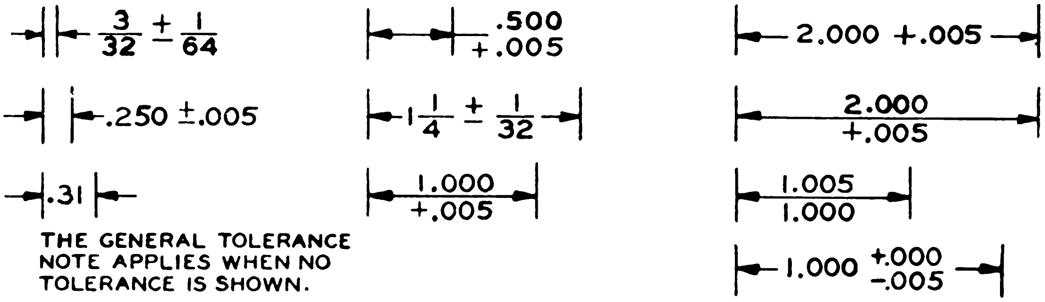
A dimension on a print gives the ideal size of the object on a drawing. This dimension is called basic dimension. However, engineers realize that it is almost impossible to achieve absolute accuracy; therefore, the possible variations from the basic dimension are figured out and are included on most prints. These leeways are called limits and tolerances.



3-34. BASIC DIMENSIONS, LIMITS, AND TOLERANCES

Limits are the allowed maximum and minimum dimensions of an object; tolerances are allowed variations from or differences between the maximum and minimum limits. The tolerance can be found by subtracting the minus-limit from the plus-limit. (The tolerance on illustration #3-34 is 1/4".)

Limits and tolerances can be shown on a print in various manners. (Refer to illustration #3-35 below.)



3-35. LIMITS AND TOLERANCES

TOPIC 5: ORDNANCE DRAWINGS

You Are Now Going To Learn:

1. Definition of ordnance drawings.
2. Types and purpose of following:
    a. Ordnance drawings.
    b. Ordnance sketches.
    c. Lists of drawings.

Discussion Points For This Topic Are:

1. Types and purpose of ordnance drawings.
2. Types and purpose of ordnance sketches.
3. Types and purpose of lists of drawings.
4. Classification of ordnance drawings.
5. Procurement of prints, sketches, and lists of drawings.
6. Review and summary.
7. Section review.
8. Written test.

ASSIGNMENT:

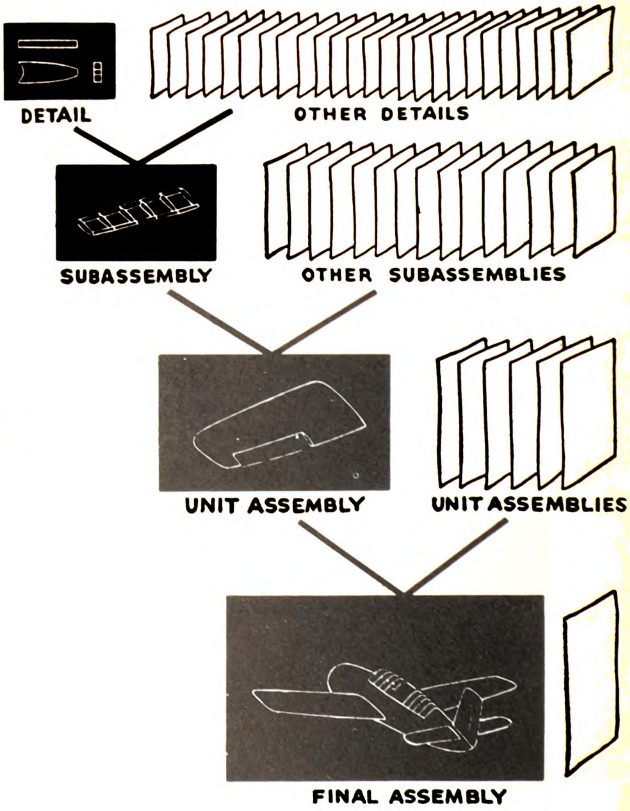
A. Reference publication:

1. Study OSTD 599 (Second Revision), Sections 3 and 5.

INFORMATION AND DISCUSSION:

An ordnance drawing is an officially approved (signed) drawing (blueprint) prepared for the Bureau of Weapons.

There are various types of ordnance drawings. A typical assembly drawing is shown in illustration #3-36 below.



3-36. TYPICAL ASSEMBLY DRAWING

Final Assembly Drawing:

A final assembly drawing shows the relationship and the identifying numbers of all parts and/or subassemblies of an entire unit. When parts have already been identified on the subassembly drawings, the part numbers are not shown again on the final assembly drawing.

Unit Assembly and Subassembly Drawing:

The unit assembly and subassembly drawings show a group of related parts of complicated ordnance equipment. These drawings are used when it is impossible to show all components of an assembly on one drawing.

Detail Drawing:

A detail drawing shows the details of a single item of the equipment. In a detail drawing, all characteristics of the item (dimensions, tolerances, types of materials, surface finishes, and protective coatings) are clearly defined.

Installation Drawing:

An installation drawing is an outline drawing showing the general configuration of the equipment and furnishing all information required for installation of the equipment onboard ship.

Outline Drawing:

An outline drawing defines the external contour of an item, usually by showing the projected views on three perpendicular planes.

Arrangement Drawing:

An arrangement drawing is an outline drawing in any perspective. This type of drawing is used for familiarization with equipment and for preliminary studying of its cofunctions with other equipment.

Personnel Arrangement Drawing:

A personnel arrangement drawing is an outline drawing that shows the approximate positions of the operating personnel.

Electrical Schematic Diagram:

An electrical schematic diagram is a drawing that shows electrical circuits and, by use of symbols, indicates the location of associated equipment parts, to facilitate troubleshooting of circuits.

NOTE: An electrical schematic is also called "Elementary Wiring Diagram" and sometimes bears this title on ordnance drawings.

Wiring Diagram:

A wiring diagram is a drawing

that shows the wiring connections within an assembly, a subassembly, an electronic set, or an electrical system.

Interconnection Diagram:

An interconnection diagram is a drawing that shows the wiring connections between subassemblies. This type of drawing is also called a cabling diagram.

Mechanical Schematic Diagram:

A mechanical schematic diagram is a drawing that shows the operational sequence of a group of mechanical parts that are related in the performance of a particular function.

Piping Diagram:

A piping diagram is a line-drawing that shows the piping connections of units or parts. Piping diagrams also may show the sequence of fluid flow in the equipment.

Hydraulic Schematic Diagram:

A hydraulic schematic diagram is a drawing that shows the functional components of hydraulic assemblies or systems. Hydraulic schematics also may show relationship of assemblies, subassemblies, or mechanical components.

NOTE: The many and various applications of hydraulics have necessitated the use of a standard symbol system which is called J.I.C. (Joint Industrial Congress) system.

Lubrication Charts:

A lubrication chart is a drawing showing the various points which require lubrication. A lubrication chart also specifies the type and frequency of lubrication.

Ordnance Sketches:

Ordnance sketches are preliminary drawings prepared during the research, experimentation, or development phases of equipment, under BuWeps contract or by task assignment. Naval activities that desire to use numbers from a unified series may request the assignment of blocks of BuWeps sketch numbers. If the sketch is prepared on a BuWeps format, the word "drawing" is deleted and replaced by the abbreviation "SK" which precedes the number.

List of Drawings:

A list of drawings (LD) is a list of ordnance equipment parts and all documents (prints, sketches, other LD's, specifications, and standards) applicable to ordnance equipment. LD's can be of the following types:

1. Principal LD:

A principal LD is prepared for each system of Naval ordnance equipment. It includes a list of major assemblies, subassemblies, individual components and accessories, also applicable documents.

2. Index to LD:

An index to an LD is a complete list of all lists of drawings (LD's) applicable to one major system of ordnance equipment.

3. Subordinate LD:

A subordinate LD is a list of drawings and parts applicable to subassemblies. These drawings and parts are not listed in the principal LD.

4. Supplementary LD:

A supplementary LD is a list of drawings or items (tools and test equipment) which provides additional information not contained in other LD's.

Not all drawings, sketches, or lists of drawings, whether prepared by a naval activity or a private contractor, are classified. However, if they require security classification, they are classified in accordance with procedures defined in the current Department of the Navy Security Manual for Classified Information, OPNAV Instruction 5510.1. Drawings are classified as follows:

1. TOP SECRET.

2. SECRET.

3. CONFIDENTIAL.

Drawings, sketches, and LD's may be procured from the Central Technical Documents Office, U.S. Naval Ordnance Plant, Louisville 14, Kentucky.

QUIZ SHEETS:

1. Photo-tracings taken of a pencil drawing are regarded as master drawings.

   True ______ or False ______.

2. An ordnance drawing is not considered official until it has been

   a. Signed.
   b. Delivered.
   c. Blueprinted.
   d. Traced.

3. A detail assembly drawing shows

   a. One assembly.
   b. One subassembly.
   c. One object.
   d. Two or more objects.

4. Ordnance sketch numbers are preceded by the letters

   a. DR.
   b. SK.
   c. SEC.
   d. LD.

5. Ordnance sketch numbers can only be assigned by BuWeps.

   True ______ or False ______.

6. Technical sketches for job orders do not have to meet established standards.

   True ______ or False ______.

7. List the four types of LD's available:

   a. ______________________.
   b. ______________________.
   c. ______________________.
   d. ______________________.

8. According to OPNAV Instruction 5510.1, ordnance drawings are classified

   a. CONFIDENTIAL.
   b. SECRET.
   c. TOP SECRET.
   d. All of the above.

9. Simplified conventions (material symbols) do not indicate specific kinds of materials.

   True ______ or False ______.

10. Draw the symbols for the following:

   a. Outline:
   b. Centerline:
   c. Hidden line:
   d. Phantom line:

11. On drawings, the designations, dimensions, and notes are tied to the corresponding parts by a

   a. Centerline.
   b. Leader.
   c. Hidden line.
   d. Phantom line.

12. Short-break lines are used to indicate that a part on the print has been shortened.

True ______ or False ______.

13. Indicate which thread-fit is the most commonly used:

a. Class 4.
b. Class 3.
c. Class 2.
d. Class 1.

14. A perspective view of an object is similar to a photograph of same.

True ______ or False ______.

15. All vertical and horizontal lines on an isometric drawing represent the true dimensions of an object.

True ______ or False ______.

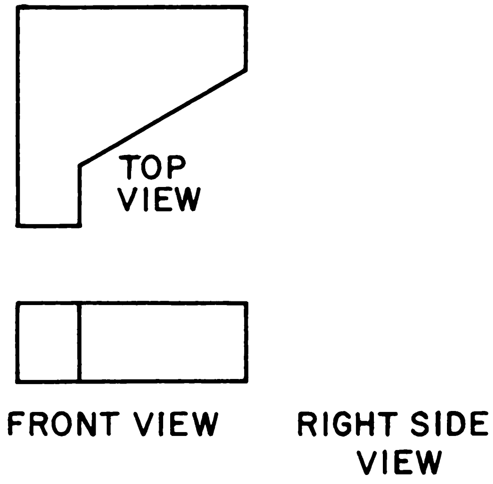
16. Lines representing horizontal lines on isometric drawings are drawn at an angle of:

a. 15 degrees.
b. 20 degrees.
c. 30 degrees.
d. 45 degrees.

17. Orthographic views are accurate and indicate true shape and size of an object.

True ______ or False ______.

18. Draw the missing view:



19. Cross-hatching is used on sectional views.

True ______ or False ______.

20. Where is the revision block usually located on a blueprint?

c

a. Upper right corner.
b. Upper left corner.
c. Lower right corner.
d. Lower left corner.

21. Indicate agency which publishes an index of Navy Department specifications:

a. Bureau of Weapons.
b. Naval Weapons Plant.
c. Bureau of Supplies and Accounts.
d. Naval Ordnance Plant, Louisville, Kentucky.

22. When tolerances are very minute (small), which type of dimensioning is preferred?

    a. Angular.
    b. Rectangular.
    c. Straight line.
    d. Circular.

Accuracy of notes checked by instructor:

Date ______________________________

Trainee's initials ____________________

Section 4

HAND TOOLS

ASSIGNMENT-DISCUSSION-PRACTICAL WORK-QUIZ SHEETS

Topic No.	Topic Title	Page
1.	Basic Rules Concerning Use of Repair Equipment ..	96
2.	General-Purpose Tools	100
3.	Measuring Tools and Gauges	104
4.	Shaping and Cutting Tools	106
5.	Soldering	108
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TOPIC 1: BASIC RULES CONCERNING USE OF REPAIR EQUIPMENT

You Are Now Going To Learn:

1. General information about repair equipment.
2. The safety regulations to be observed while working with repair tools.

Discussion Points For This Topic Are:

1. Selection of proper tools.
2. Types of repair tools.
3. Planning of work.
4. Basic rules applicable to repair equipment.
5. Safety precautions.
6. Review and summary.

INFORMATION AND DISCUSSION:

Each technician must be familiar with the techniques required for repair and maintenance of ordnance equipment and must know which tool to select and how to perform a job. Whether he is going to repair a guided missile launching system, a gun, a power drive unit, or adjust equipment for proper operation, he must possess basic skill in laying out the job, and in measuring, cutting, testing, checking, and other related procedures.

Tools can be classified as follows:

1. Handtools (general-purpose tools).
2. Power tools.
3. Measuring tools and gauges.
4. Special tools.

Handtools are hand-powered and hand-operated. They are designed to perform mechanical operations. Examples of typical handtools are hammers, screwdrivers, and saws.

Power tools can be either electrically or pneumatically powered and are hand-operated. They are designed to save time and manpower. Examples of typical power tools used by gunner's mates are soldering guns, drills, and grinders.

Measuring tools and gauges are used for measuring and for layout work. Accurate measurements are essential for proper fitting and troublefree equipment operation. To test and check the various types of power equipment, special gauges are used. The measuring tools and gauges range from a simple wooden or steel ruler to highly intricate micrometers.

Special tools are used only for one purpose and only on one type of equipment. They are supplied by BuWeps, and instructions for their proper use are provided in the OP applicable to the equipment.

Before a job is started, all work procedures should be planned step by step (on paper, if necessary), and the proper tools should be selected, to complete the job with the highest degree of accuracy in the shortest time.

Tools which are not actually in use should be kept in their proper places. After a job is completed, all tools should be properly stored.

Basic Rules Applicable to Repair Equipment:

1. The quality and type of all tools shall conform with Navy standards.

2. All tools in active use shall be properly maintained. Defective tools shall be returned to the toolkeepers.

3. Portable electric and pneumatic tools shall be kept in the best condition possible. Switches, control valves, electric cord and hose connections shall be frequently checked.

4. To prevent damage, tools shall be carefully handled. They shall not be piled in drawers or dropped on hard surfaces. Faulty tools shall not be used, since a cracked hammer handle, a rounded screwdriver tip, or a punch with improper point or mushroomed head may cause serious accidents.

5. To increase leverage, extensions on tool handles shall not be used.

Safety Precautions:

It is extremely important that all persons working with tools realize the possibility of injury. The following safety precautions are therefore included to prevent or minimize personal injury:

1. Familiarize yourself with the composition and consistency of the material you will be working with and select the proper tool. Do not use a tool for other purposes than originally intended. For instance, a screwdriver is designed to loosen or tighten screws; do not use it as a chisel or pry-bar.

2. Use only sparkproof tools near explosives or in an explosive atmosphere.

3. Use torches and soldering irons with extreme care, to prevent burns and explosions. Place soldering iron so that the hot point cannot come in contact with flammable material or with your body.

4. Always wear goggles when chipping metal and when grinding

edges of tools.

5. Before using the tools, make sure that all tool-handles are securely attached.

6. For electrical work, use only tools with insulated handles.

7. Exercise extreme caution when handling edged and pointed tools. Do not carry them in your pocket. When you use a knife (except a spoke shave or draw knife), always cut away from your body.

8. Do not grasp a tool-handle in such a way that your fingers can be pinched or jammed if the tool slips.

9. Hold chisels, punches, and drifts in the safest way possible - between thumb and other four fingers; on horizontal cuts, hold your palm up.

10. When working with sledge hammers on chisels or other similar shock tools, use a tool holder to prevent injury in the event that the sledge misses the tool.

11. Securely tighten the drill chucks with the key provided. Do not use wrenches or pliers to tighten a chuck.

12. Do not use an oily or greasy tool - it may slip out of your hand and cause injury.

13. Make sure that the work to be cut, sheared, chiseled, filed, etc., is steadied and secured, to prevent the tool from slipping.

14. Hold driving tools correctly to prevent them from slipping off the work surface.

15. When using jacks to lift heavy objects, use blocking or other supports to prevent the object from falling if the jack slips.

NOTE: Component repair techniques will be covered during the course of instruction.

TOPIC 2: GENERAL-PURPOSE TOOLS

You Are Now Going To Learn:

1. Types and use of general-purpose tools.

Discussion Points For This Topic Are:

1. Hammers.
2. Screwdrivers.
3. Pliers.
4. Wrenches.
5. Torque wrenches.
6. Punches.
7. Vises.
8. Abrasives.
9. Review and summary.

ASSIGNMENT:

A. Reference publications:

   1. Study NavPers 10085-A, pages 1 through 9, 24 through 28, 50, 51, and 159.
   2. Optional reading list:
      a. TM9-243.
      b. MC 835 (Shop Theory).

INFORMATION AND DISCUSSION:

The discussion points listed in this topic are thoroughly covered in the reading assignment, except for abrasives which are discussed in the following text.

Abrasives are materials that wear away, or cut away, other materials by friction. The primary requirement for a satisfactory abrasive is that it must be harder than the material on which it is used. Abrasives vary from coarse grits, used for fast cutting, to powders as fine as talcum, used for polishing.

Natural abrasives are made from materials in the natural state, for example, flint and garnet grits of ordinary sandpaper.

Emery and corundum are other commonly used natural abrasives. Emery consists of about 60 percent aluminum oxide and 40 percent iron oxide. Corundum consists of about 85 percent aluminum oxide and 15 percent iron oxide.

Artificial abrasives have largely replaced natural abrasives for use on metal. The two main artificial abrasives are silicon carbide and aluminum oxide. Silicon carbide is made by heating coke, sawdust, and pure silica sand to a high temperature in an electric furnace. Aluminum oxide is also made in an electric furnace, but it is made from bauxite ore from which aluminum is also made.

Abrasive materials are crushed into small particles, grits or grains, which are used in the manufacture of sheets, belts, grinding wheels, etc.

The size of an abrasive grain is determined by mesh measurement and designated by the number of the mesh through which the grain will pass. For example, if a sieve has 46 spaces per linear inch, the grains that just pass through that mesh are size 46. Abrasive grain sizes range from 4 to 280. Powder-fine abrasive flour sizes range from 280 to 600. In all there are 28 standard sizes. Grain sizes are marked on abrasive sheets, disks, belts, and grinding wheels.

Oilstones are made of silicon carbide, aluminum oxide, or natural stone and are normally used for honing edged tools or for removing the "wire-edge" left by the grinder.

Natural stones have exceptionally fine grains and are unsurpassed for putting razor edges on fine cutting tools. The finest natural stone is Hard Arkansas. Other good stones are Soft Arkansas and Washita.

Powdered abrasives are used for lapping, valve grinding, polishing, and buffing. Pumice stone is a light gray natural powder that is used to clean metal surfaces and to

Garnet Silicon Carbide Aluminum Oxide	Flint Paper	Emery Cloth	
400			Very Fine
320 or 10/0			
240 or 7/0	5/0		
220 or 6/0	4/0		
	3/0		Fine
180 or 5/0		3/0	
150 or 4/0		2/0	
	2/0		
120 or 3/0			
	0	0	
100 or 2/0			
	1/2	1/2	Medium
80 or 0		1	
	1	1 1/2	
60 or 1/2			
		2	
50 or 1	1 1/2		
40 or 1 1/2	2	2 1/2	Coarse
36 or 2			
30 or 2 1/2	3	3	
24 or 3	3 1/2		Very Coarse
20 or 3 1/2			
16 or 4			

4-1. COMPARATIVE CHART OF ABRASIVE GRAIN SIZES smooth painted, enameled, varnished, and lacquered surfaces. Pumice is used with oil or water and rubbed with a cork or felt pad. Grain sizes of pumice are F (fine), FF (medium fine), and FFF (very fine).

Rotten stone is a fine gray powder used with paraffin oil to put a high polish on a finished surface.

Valve-grinding compound is made of fine abrasive powders (emery or artificial) mixed with oil or grease. The abrasive action is obtained by coating the valve face with compound and rubbing it against the valve seat.

Crocus cloth is an extremely fine polishing abrasive. The cloth backing is coated with ferrous oxide. Crocus cloth is used like emery cloth; however, it has a much smoother surface.

Rouge is the polishing material used for putting a "supershine" on metal surfaces. It is made of ferric oxide and is supplied in bar form.

TOPIC 3: MEASURING TOOLS AND GAUGES

You Are Now Going To Learn:

1. Types, use, and care of measuring tools and gauges.

You Will Acquire Skill In:

1. Reading the machinist steel rule.
2. Using inside and outside calipers.
3. Reading vernier-scale micrometers.
4. Using feeler gauges.

Discussion Points For This Topic Are:

1. Common machinist steel rules.
2. Calipers.
3. Micrometers.
4. Dial indicators.
5. Feeler gauges and depth gauges.
6. Review and summary.

ASSIGNMENT:

A. Reference publications:

1. Study NavPers 10085-A, pages 28 through 38, 40 through 44, 90 through 102, and 116 through 119.
2. Optional reading list:
    a. TM9-243.
    b. MC 835 (Shop Theory).

INFORMATION AND DISCUSSION:

The discussion points listed in this topic are thoroughly covered in the assignment. While studying, pay particular attention to reading of micrometers.

Perform the following operations:

1. Take various measurements with a machinist steel scale.
2. Take inside and outside caliper readings.
3. Take micrometer readings.
4. Take feeler-gauge readings.

TOPIC 4: SHAPING AND CUTTING TOOLS

You Are Now Going To Learn:

1. Types, use, and care of shaping and cutting tools.

You Will Acquire Skill In:

1. Using the hacksaw for cutting light metal.
2. Filing metal.
3. Using hand snips for cutting light metal.

Discussion Points For This Topic Are:

1. Chisels.
2. Hacksaws.
3. Files.
4. Hand snips.
5. Review and summary.

ASSIGNMENT:

A. Reference publications:

   1. Study NavPers 10085-A, pages 10 through 14, 150 through 152, 155 through 159, and 225 through 230.
   2. Optional reading list:
      a. TM9-243.
      b. MC 835 (Shop Theory).

INFORMATION AND DISCUSSION:

The discussion points listed in this topic are thoroughly covered in the assignment. While studying, pay particular attention to the description of files.

Perform the following operations:

1. Cut light metal brass, tinplate, copper, or sheet iron with hand snips.
2. Cut metal, too thick or too hard to cut with hand snips, with a hacksaw.
3. Use a file for cutting and smoothing metal.

TOPIC 5: SOLDERING

You Are Now Going To Learn:

1. Types, use, and care of flux, solder, and soldering equipment (coppers, irons, and guns).

You Will Acquire Skill In:

1. Soldering electrical connections.

Discussion Points For This Topic Are:

1. Soldering equipment (coppers):
    a. Nonelectric irons.
    b. Electric irons.
    c. Guns.
2. Flux.
3. Solder.
4. Soldering procedures.
5. Review and summary.

ASSIGNMENT:

A. Reference publications:

1. Study NavPers 10085-A, pages 188 through 194, and NavPers 10086-A, pages 110 through 116.
2. Optional reading list:
    a. TM9-243.

Perform the following operations:

1. Properly tin an electric soldering iron or gun.
2. Make and solder wire splices.
3. Solder lugs to electrical wire.

TOPIC 6: DRILLING AND REAMING

You Are Now Going To Learn:

1. Types, use, and care of drilling and reaming tools.

You Will Acquire Skill In:

1. Drilling holes in metal, in preparation for tapping.

Discussion Points For This Topic Are:

1. Drills.
2. Twist drills.
3. Reamers.
4. Countersinks.
5. Counterbores.
6. Drill gauges.
7. Review and summary.

ASSIGNMENT:

A. Reference publications:

  1. Study NavPers 10085-A, pages 14 through 16, 111, 133, 147 through 150, 162, and 163.
  2. Optional reading list:
     a. TM9-243.
     b. MC 835 (Shop Theory).

INFORMATION AND DISCUSSION:

The discussion points listed in this topic are thoroughly covered in the assignment.

Perform the following operations:

1. Drill holes in metal, in preparation for tapping.
2. Countersink a hole.

TOPIC 7: THREAD-CUTTING

You Are Now Going To Learn:

1. Types, use, and care of thread-cutting tools.

You Will Acquire Skill In:

1. Cutting internal and external threads.

Discussion Points For This Topic Are:

1. General information about threads.
2. Screw pitch gauges.
3. Taps.
4. Dies.
5. Tap extractors.
6. Review and summary.

ASSIGNMENT:

A. Reference publications:

1. Study NavPers 10085-A, pages 44 through 49, 99, 101, 163 through 172, and 185 through 188.
2. Optional reading list:
    a. TM9-243.
    b. MC 835 (Shop Theory).

INFORMATION AND DISCUSSION:

The discussion points listed in this topic are thoroughly covered in the assignment. While studying, pay particular attention to description of taps and dies.

Perform the following operations:

1. Cut internal and external threads.

TOPIC 8: TUBE-FABRICATING TOOLS

You Are Now Going To Learn:

1. Types, use, and care of tube-fabricating tools.

You Will Acquire Skill In:

1. Cutting, flaring, bending, and fitting tubing.

Discussion Points For This Topic Are:

1. Tube cutting.
2. Tube flaring.
3. Tube bending.
4. Tube fitting.
5. Review and summary.

ASSIGNMENT:

A. Reference publications:

   1. Study NavPers 10085-A, pages 54, 56, 57, 175, and 183 through 185.
   2. Optional reading list:
      a. TM9-243.

INFORMATION AND DISCUSSION:

The discussion points listed in this topic are thoroughly covered in the assignment.

Perform the following operations:

1. Cut, flare, and bend tubing.

TOPIC 9: SPECIAL TOOLS

You Are Now Going To Learn:

1. Types, use, and care of special ordnance equipment tools.

Discussion Points For This Topic Are:

1. Gasket cutters.
2. Bearing scrapers.
3. Grease guns and grease pumps.
4. Bearing and gear pullers.
5. Review and summary.

ASSIGNMENT:

A. Reference publications:

   1. Study NavPers 10085-A, page 28.
   2. Study TM9-243, pages 123 through 129 and 162 through 166.

INFORMATION AND DISCUSSION:

The discussion points listed in this topic are thoroughly covered in the assignment, except for grease guns which are discussed in the following text.

Grease guns are manufactured in many shapes and sizes and can be operated by power or by hand. Normally, gunner's mates will have more use for the hand-operated grease gun than for the power-operated gun.

Depending on the method used for loading, grease guns are divided into two types. One type is loaded by removing the cap which contains the handle and stem and, by use of a paddle or spatula, filling the body of the gun with grease. This loading method exposes the lubricant to dirt and moisture and is usually messy.

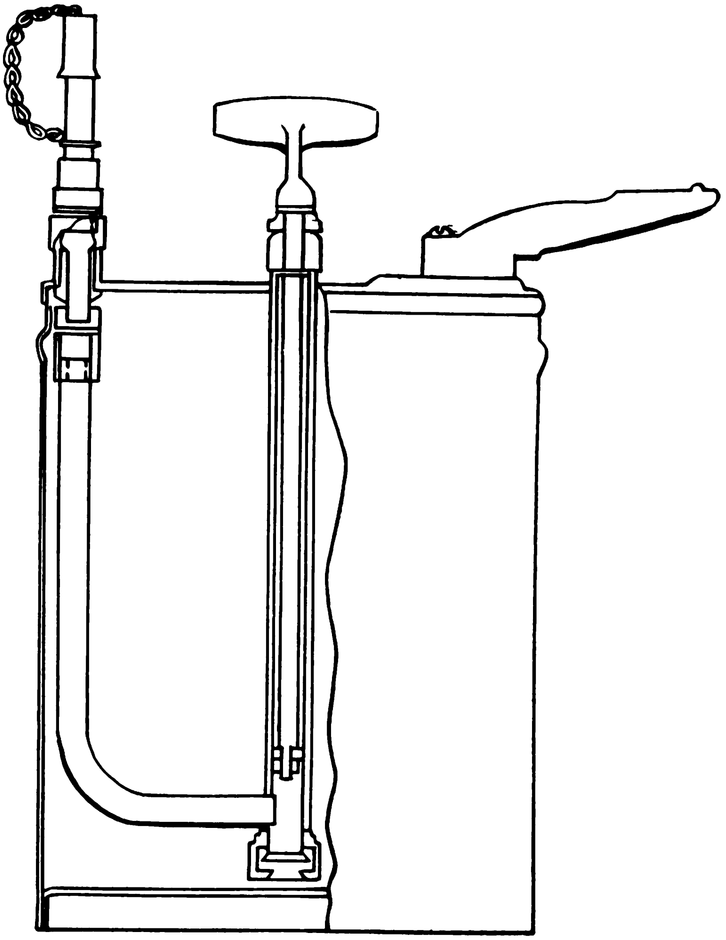
The other type of hand-operated grease gun is loaded by removing a cap nut from the end of a hollow handle and forcing grease through the handle with a hand gun loader. This loading method is faster and cleaner.

Nozzles for various types of fittings may be attached to hand-operated grease guns.

The lever-operated hand grease gun is a recent type of gun. It performs better than the Zerk type.

The hand gun loader is a 25-pound metal container equipped with a hand-operated pump. Pump fittings mate with the grease gun handle opening.

The bucket-type lubricant pump has a loader adapter and

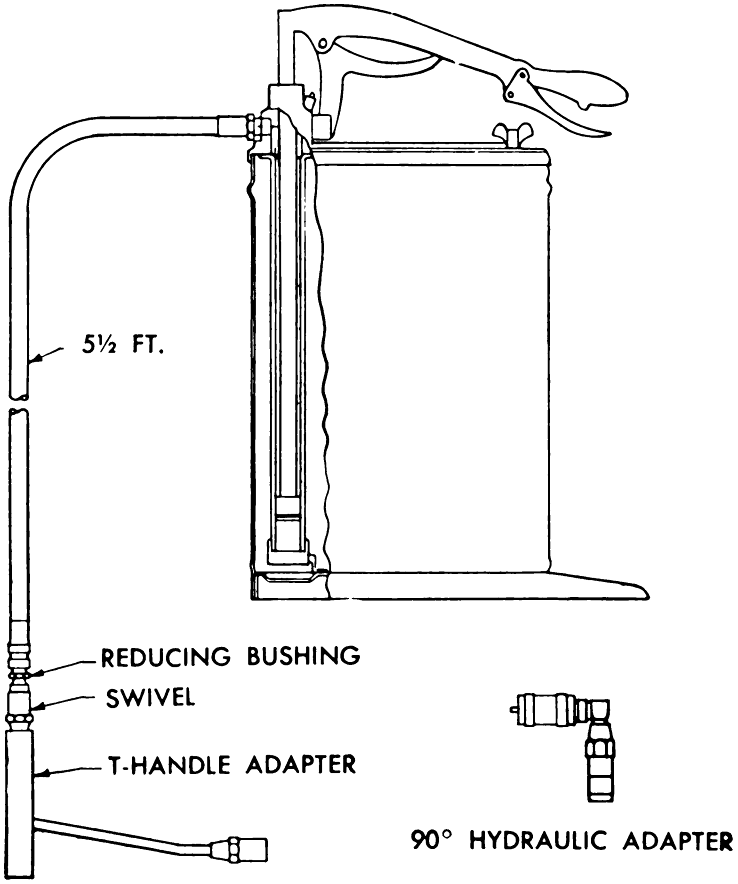


4-2. HAND GUN LOADER

loader valve which are used during loading of a grease gun. The loader delivers lubricant only when the grease gun is placed on the loader valve. This type of loading protects the lubricant from contamination and provides an extra supply of lubricant when the supply in the gun is expended.

The bucket-type hand-operated lubricating pump (refer to illustration #4-3 on the following page) should be used for lubrication requiring large quantities of grease. The bucket-type pump holds a 25-pound supply of lubricant and is lever operated. Supplied with the pump are a 10-foot hose with a hydraulic T-handle adapter and a 90° adapter for working in cramped spaces. Various couplers and adapters may be attached to the hose for use on different types of fittings.

It would be ideal to have a grease gun for each type of lubricant to be used on a gun or mount. However, this is seldom, if ever, possible.



4-3. HAND-OPERATED GREASE PUMP

Therefore, grease must be removed from the gun when several types of grease are used to complete lubrication. A good practice to follow is to be sure that there is no grease left in the gun before it is to be used for another type of grease.

Perform the following operations:

1. Cut round gaskets from sheet stock.

TOPIC 10: METAL FASTENERS

You Are Now Going To Learn:

1. Various types of metal fasteners and their uses.

You Will Acquire Skill In:

1. Identifying various types of metal fasteners.

2. Practical use of handtools.

Discussion Points For This Topic Are:

1. Screws.
2. Bolts.
3. Nuts.
4. Washers.
5. Keys and pins.
6. Rivets and rivet sets.
7. Review and summary.
8. Section review.
9. Written test.

ASSIGNMENT:

A. Trainee's Guide:

   1. Study Section 4, Topic 10.

INFORMATION AND DISCUSSION:

Metal fasteners are used extensively onboard ship for maintaining and repairing mechanisms and installations. In this topic the various types of metal fasteners will be discussed.

Screws:

Small screws, used for the assembly of metal parts, are generally called machine screws. They are usually screwed into holes that have been tapped with matching threads, but may also be used with square or hex nuts.

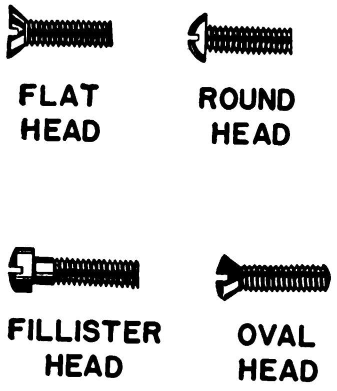
Most machine screws are made of steel or brass and may be chromium- or cadmium-plated to prevent corrosion. For special purposes, machine screws are manufactured of aluminum or stainless steel. The latter (stainless steel) are very strong and have a high resistance to the corrosive action of salt water.

Since screws are made with a wide variety of lengths, diameters, and head shapes, a complete description of a machine screw must include the following features:

1. Length in inches.
2. Gauge No. and number of threads per inch.
3. Head shape.
4. Material of which manufactured.
5. Finish.

The following is a typical example of a machine screw description:

> 1/2 inch, 8-32, round head, brass, chromium-plated. (8-32 means screw gauge No. 8, 32 threads per inch.)



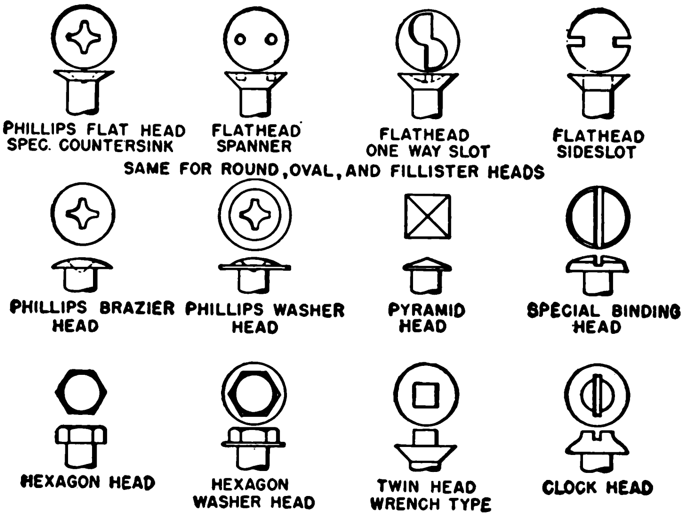
4-4. COMMON MACHINE SCREWS

Machine screws are driven, depending on the type of their heads, with screwdrivers or wrenches: Slotted heads are driven with plain screwdrivers, phillips heads with phillips screwdrivers, and hexheads are turned with socket wrenches.

The most frequently used types of machine screws are shown in illustration 4-4.

The special type screws, shown in illustration 4-5, require special driving tools which are usually included in a kit that comes with the machine or installation for which these screws are intended.

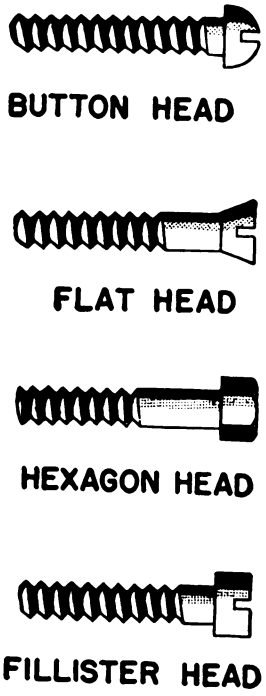
Cap screws may have square, hexagonal, flat, button, or fillister heads. For movable parts, fillister-head screws should be used, because they are sunk into counterbored holes; for fixed parts, hex heads are generally used.



4-5. SPECIAL MACHINE SCREWS

The strongest cap screws are those made of alloy steel; they can withstand stress, strain, and shearing.

Certain special cap screws are made of stainless steel; they are used on machinery exposed to salt water which usually soon corrodes and "freezes" the threads of ordinary steel screws.



4-6. CAP SCREWS

Cap-screw heads may be manufactured with small holes, through which a safety wire is run, to prevent loosening of the screw.

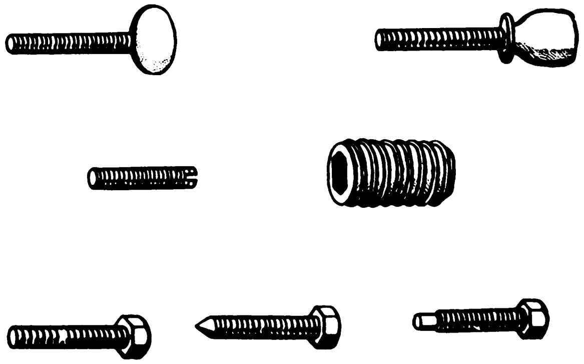
Set screws are used to secure small pulleys, gears, and cams to shafts, and to achieve precise adjustments of machine parts. Set screws are classified according to their diameter, thread, head shape, and point shape.

The classification according to point shape is very important, since the shape of the point indicates the holding characteristics of the set screw. Cone-point or dog-point set screws provide the best holding features, because they fit into the matching recesses in the shafts against which they bear.

Headless set screws (slotted, allen, or bristo-type) are used on movable parts, because these screws are threaded from point to head and do not protrude above the surface.

For fixed parts, common set screws with square heads, threaded from the point to the shoulder of the head, are used.

To hold sections of sheet-metal, fiber, plastic, etc., sheet-metal screws are used. These screws are usually classified as type A and type Z.



4-7. SET SCREWS AND THUMB SCREWS

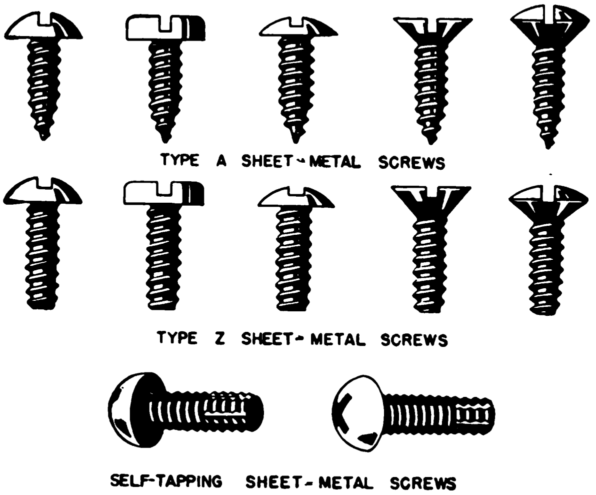
Type A screws have a sharp point and are similar to wood screws, with the exception that the threads of a type A screw extend from the point to the head, while the shank of a wood screw is only partly threaded.

Type Z screws have blunt points and the same kind of threads as type A screws.

For heavier metal sheets, self-tapping sheet-metal screws are used.

Holes for sheet-metal screws are drilled or punched and must be of the minimum diameter of the screw to be used.

Sheet-metal screws are often called self-tapping screws; this designation is not correct however: A self-tapping screw has a tap-end which actually cuts threads.


TYPE A SHEET-METAL SCREWS

TYPE Z SHEET-METAL SCREWS

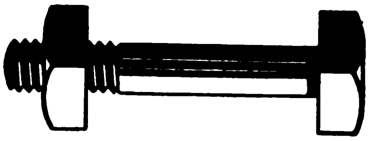
SELF-TAPPING SHEET-METAL SCREWS

4-8. SHEET METAL SCREWS

Bolts:

Machine bolts are furnished rough, semifinished, or finished. They are manufactured with a wide variety of diameters, lengths, thread pitches, and head shapes. Diameters of machine bolts range from 3/16 to 3/4 inch, and their lengths from 1/2 inch to 30 inches. (Larger bolts are seldom carried in stock, but can be made on special order.) Most bolts have coarse (NC) threads.

Machine bolts are used to assemble frames and structures of ships, buildings, and bridges. They are also used on temporary structures which have to be easily dismantled. Certain bolts are manufactured with holes drilled near the end of the threaded part to accommodate cotter keys or safety wires.

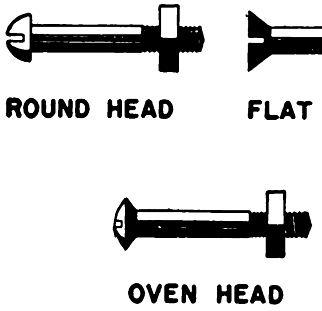


4-9. MACHINE BOLT

Stove bolts are small and were originally developed (as their name implies) to be used on stoves, but they can also be used on other equipment where no vibration is present to loosen the nuts.

Stove bolts have especially coarse threads which provide a loose (or free) fit for the threads of square nuts.

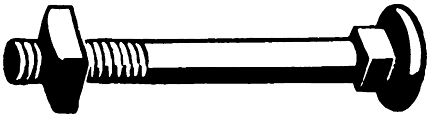
Stove bolts may have round, flat, or oven heads and either regular or phillips slots.



4-10. STOVE BOLTS

Carriage bolts have brazier (or dunbar-shaped) heads and short square shanks right under their heads. The square shanks prevent the bolts from turning. Carriage bolts are most frequently used on wood, but may also be used on metal.

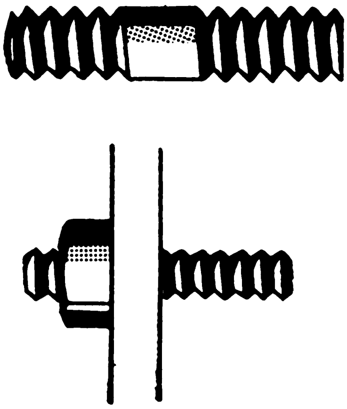
Square nuts and flat washers are used with carriage bolts.



4-11. CARRIAGE BOLT

Studs, also called headless bolts, are threaded at both ends: One end is made to be screwed into a tapped hole, the other to accommodate the nut. Studs are used to hold the covers on ordnance equipment, since, to lift the covers, only the nuts have to be taken off, and the studs do not have to be removed.

Studs are used in castings, and therefore they usually have coarse (NC) threads.

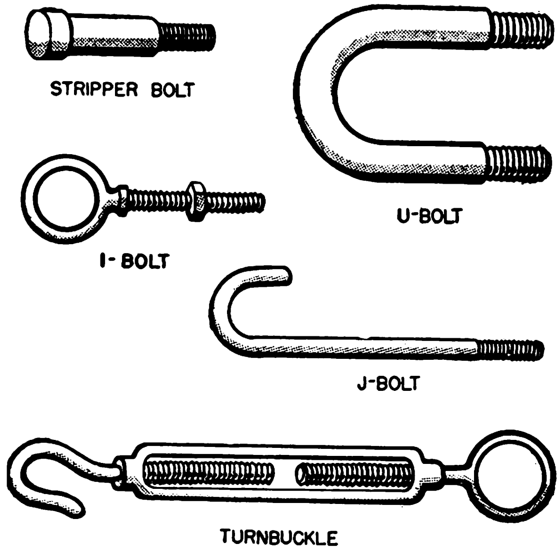


4-12. STUDS

Stripper bolts are used for the same purposes as cap screws. Stripper bolts have a precision-ground and polished shoulder between the head and the threaded part. This shoulder is used as shaft for gears or cams and as fulcrum for levers.

Stripper bolts have standard fine (NF) threads. The heads of stripper bolts may be hexagonal or fillister, with allen or bristo-type slots.

Numerous other types of fasteners have been developed to be used on equipment where regular fastening devices did not prove to be satisfactory. (Refer to illustration #4-13 and note the I (eye)-, J-, and U-bolts which are actually draw-bolts and rather typical examples of special fasteners.)



4-13. SPECIAL FASTENERS

Nuts:

Square or hexagonal nuts may be supplemented by special nuts, for instance jam nuts, which are used over standard hex nuts to lock the hex nuts in proper position. The jam nuts are about half as thick as the standard hex nuts and have washer faces.

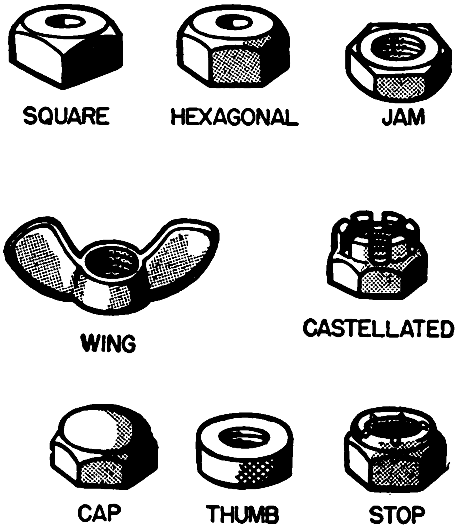
A castellated nut is slotted for insertion of a cotter key through its slots and a hole in the bolt, to prevent the nut from loosening.

Wing nuts are used for equipment which requires frequent adjustment.

Where appearance is an important feature, cap or acorn nuts are used. The cap and acorn nuts are usually made of chromium-plated brass.

Thumb nuts are knurled and can be turned by hand to ease assembly and disassembly.

Elastic stop nuts are used on equipment which requires positive securing of the nuts. These nuts have built-in fiber or composition washers that are automatically pressed against the screw threads, to provide the tension necessary for holding the nuts.



4-14. TYPES OF NUTS

Washers:

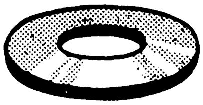
Washers are manufactured in many sizes and shapes. Basically, however, they can be divided in two types: common flat washers and lock washers.

Common flat washers are used to back up bolt heads and nuts and to provide larger bearing surfaces. They also prevent damage to the metal surfaces through which the bolts pass.

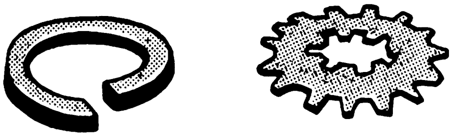
Split lock washers are spring-hardened, to prevent loosening of the nuts due to vibration: One end of a split washer cuts into the nut, while the other end holds the material to prevent slippage.

Shakeproof lock washers may be obtained in several patented designs, shapes, and sizes. They have teeth or lugs to hold the material and the nut.

Star lock washers are similar in appearance to shakeproof washers. Star lock washers may be knurled to fit the shaft or may be equipped with one inner lug which fits into a keyway of a shaft. When the washer is installed, at least one of its outer lugs is bent to fit into the recesses on the flat side of a nut, to lock the nut in proper position.



FLAT WASHER



SPLIT LOCK WASHER

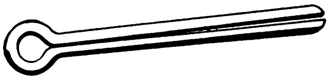
SHAKE PROOF WASHER

4-15. TYPES OF WASHERS

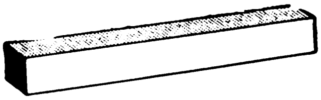
Keys and Pins:

Cotter keys are used to secure castellated nuts to bolts or rods and are also used as stops and holders on shafts or rods.

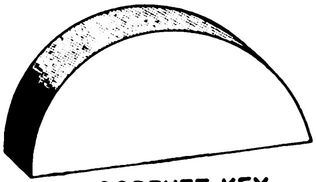
Square keys and woodruff keys are used to hold handwheels, gears, cams, and pulleys on shafts and arbors. These keys fit into keyways and, when properly fitted and seated, enable the equipment to carry heavy loads.



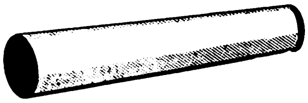
COTTER KEY



SQUARE KEY



WOODRUFF KEY



STEEL TAPER PIN

STEEL DOWEL PIN

4-16. KEYS AND PINS

Taper pins are used to locate the exact position of matching parts and to secure small pulleys and gears to shafts. They usually are equipped with a taper of 1/4 inch per foot. For proper fitting, the holes for taper pins must be reamed with tapered reamers.

Dowel pins are used to position and to align whole units or separate parts of an assembly. The pins are used where frequent assembly and disassembly is required. One end of a dowel pin is chamfered and is usually .001 to .002 inch wider in diameter than the specified size, allowing the hole for the pin to be reamed to ensure a closer fit.

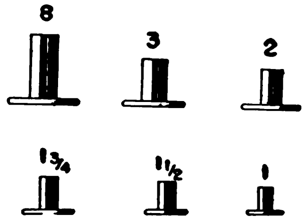
Rivets and Rivet Sets:

Rivets are permanent fasteners which cannot be reused. The holes for rivets are drilled or punched.

Rivets must be carefully spaced and aligned. The diameter and length of a rivet to be used must be determined according to the construction features of the material to be riveted.

On thin sheet metal, tinner rivets are used. They have flat heads, are made of soft iron or of steel, and are usually tin-coated to prevent corrosion.

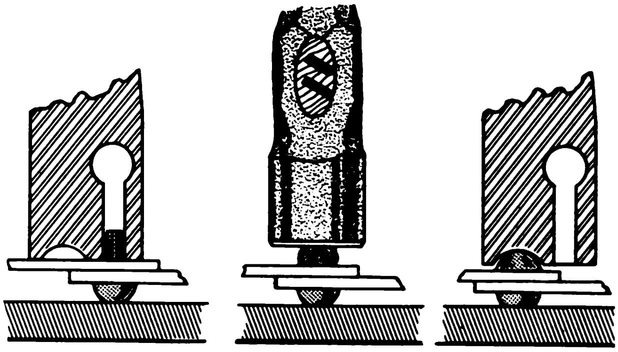
Rivet sizes are classified by numbers according to the weight of 1,000 rivets. For instance, rivets of which 1,000 weigh 1 pound are classified #1, of which 1,000 weigh 2 pounds, #2, etc. The most frequently used are 1-pound and 2-pound rivets. They are usually sold in 1-pound packages or boxes.



4-17. TINNER'S RIVETS

All rivets of one size are identical. The length of each rivet is in proportion to its weight and diameter.

Rivet sets are available in several sizes. They are used for pulling the rivet heads tightly against the metal sheets and for pressing together the sheets to be riveted. After a rivet is upset (headed on its headless end) with a riveting hammer, the rivet set is used to round up the upset end.



4-18. USE OF RIVET SET

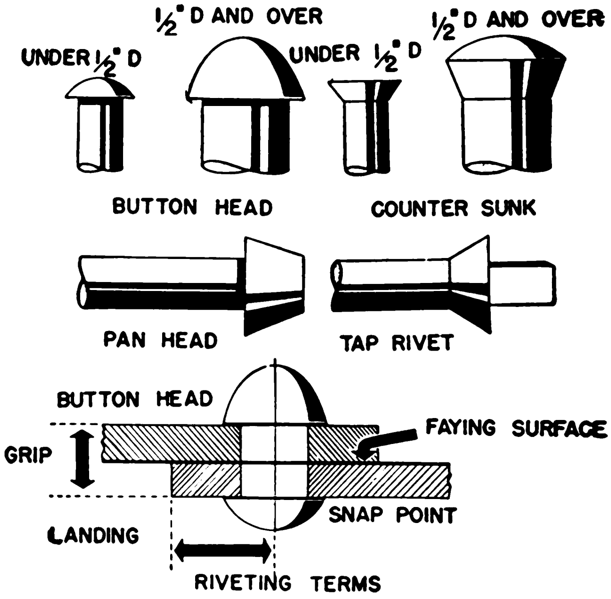
Where appearance is a main concern, small round-head rivets made of iron, brass, aluminum, or copper are used, since the appearance of the headless end of a round-head rivet can be improved by using a rivet set of the proper size.

Structural rivets are used on all types of steel frames and structures, to fasten plates and other parts of a ship. Structural rivets are usually heated before they are driven into the material; when they cool off, they contract and hold the riveted parts tighter together. Heated rivets are also easier to drive.

The diameters of structural rivets usually vary from 1/4 inch to 1-1/4 inches, but for thicker material, larger rivets have to be used.

The distance from the center of a rivet to the edge of a sheet should never be less than 1-1/2 times the diameter of the rivet. The space between rivets should be from 3 to 8 times the diameter of the rivet , measured from the center of one rivet to the center of another.

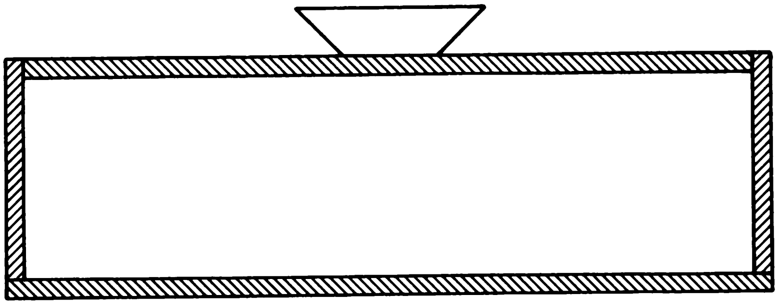
A rivet may be removed by cutting off its head with a cold chisel and punching out the body of the rivet. To ease removal of a small rivet, a hole can be drilled through its head (the hole should be drilled through the head only), and the weakened head can be cut off with a cold chisel.



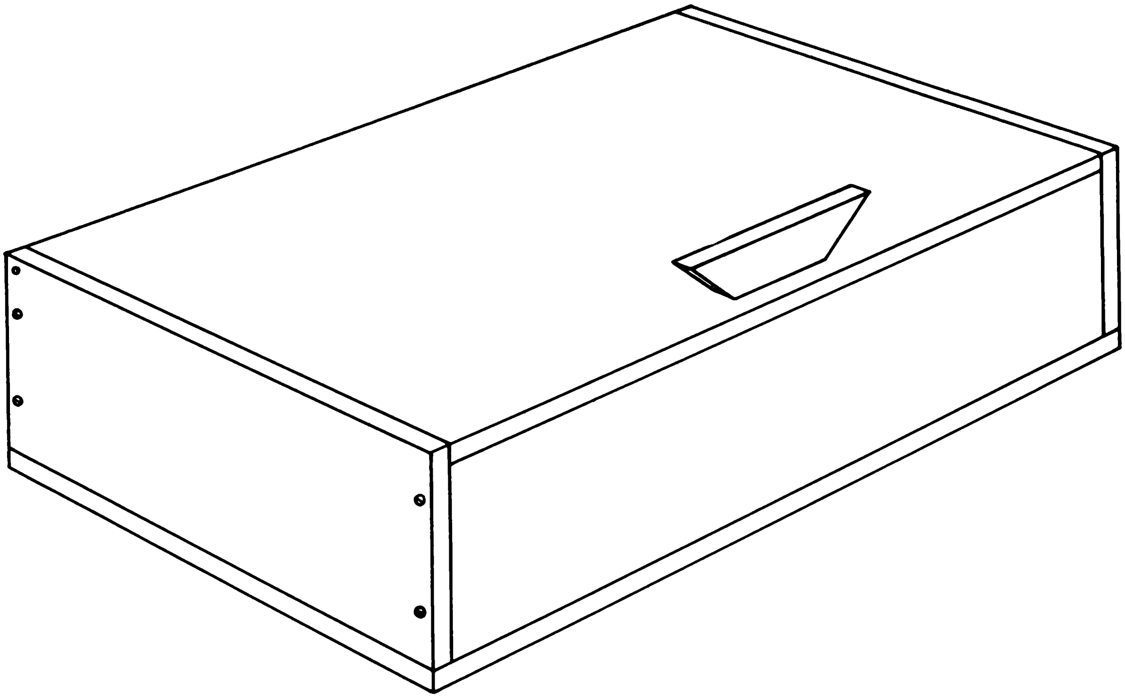
4-19. STRUCTURAL RIVETS

Perform the following operations:

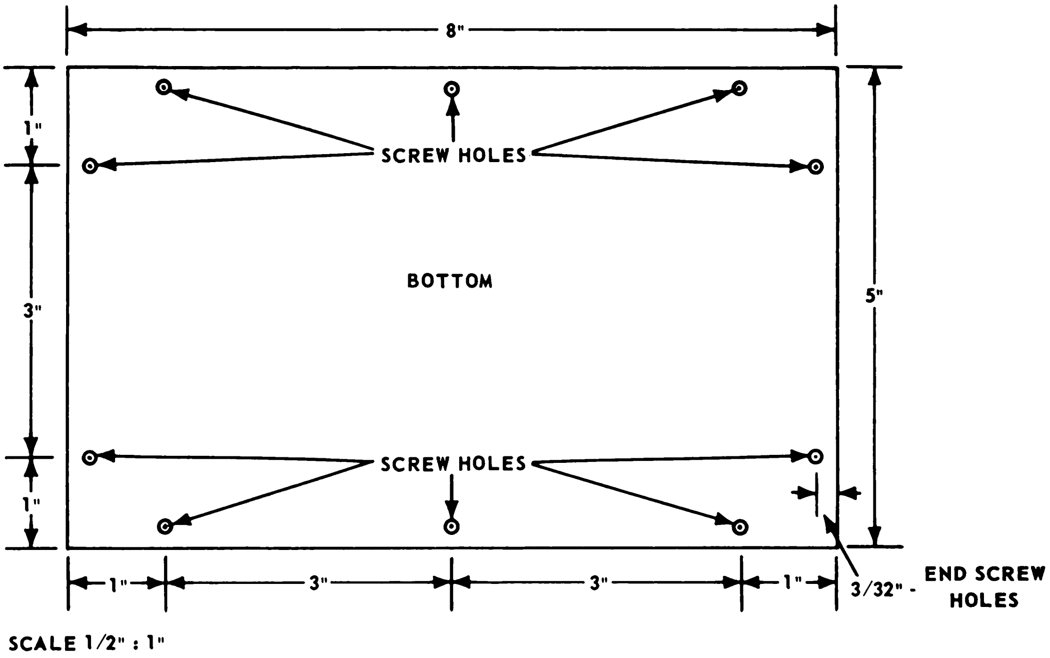
1. Study the following sketches and drawings.
2. Assemble all necessary tools and materials before starting project.
3. Proceed with project, construction of aluminum box:
   a. Follow dimensioning on sketches; do not take measurements from dimensions on sketches.
   b. Cut all pieces of box before performing any drilling or tapping operations.



FRONT VIEW



4-20. ALUMINUM BOX, FRONT AND PERSPECTIVE VIEWS



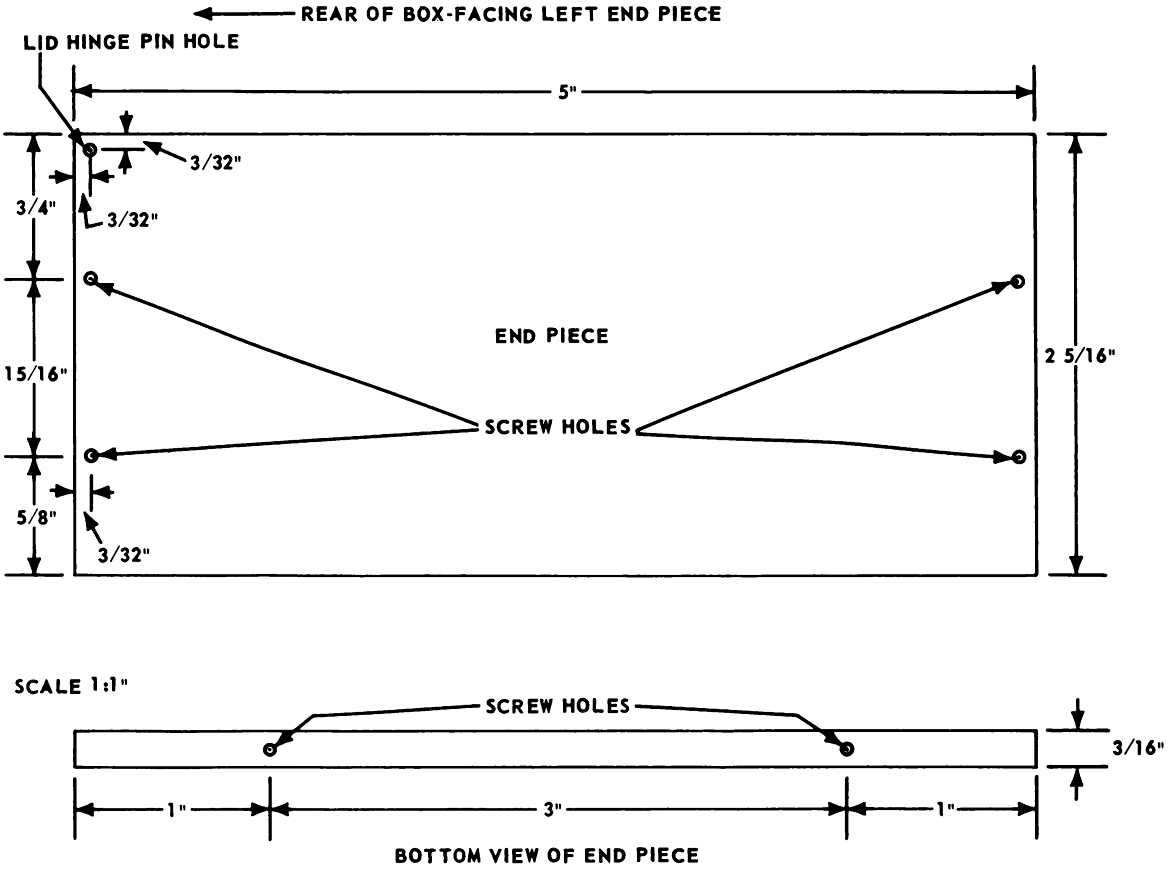
4-21. ALUMINUM BOX, BOTTOM VIEW

4. Aluminum box, bottom:

   a. Cut bottom, to above specifications, from 1/8" aluminum stock.

   b. Using .089" drill, drill screw holes.

   c. Countersink screw holes to take #4, 1/2", hardened steel, self-tapping screws.



4-22. ALUMINUM BOX, END PIECE

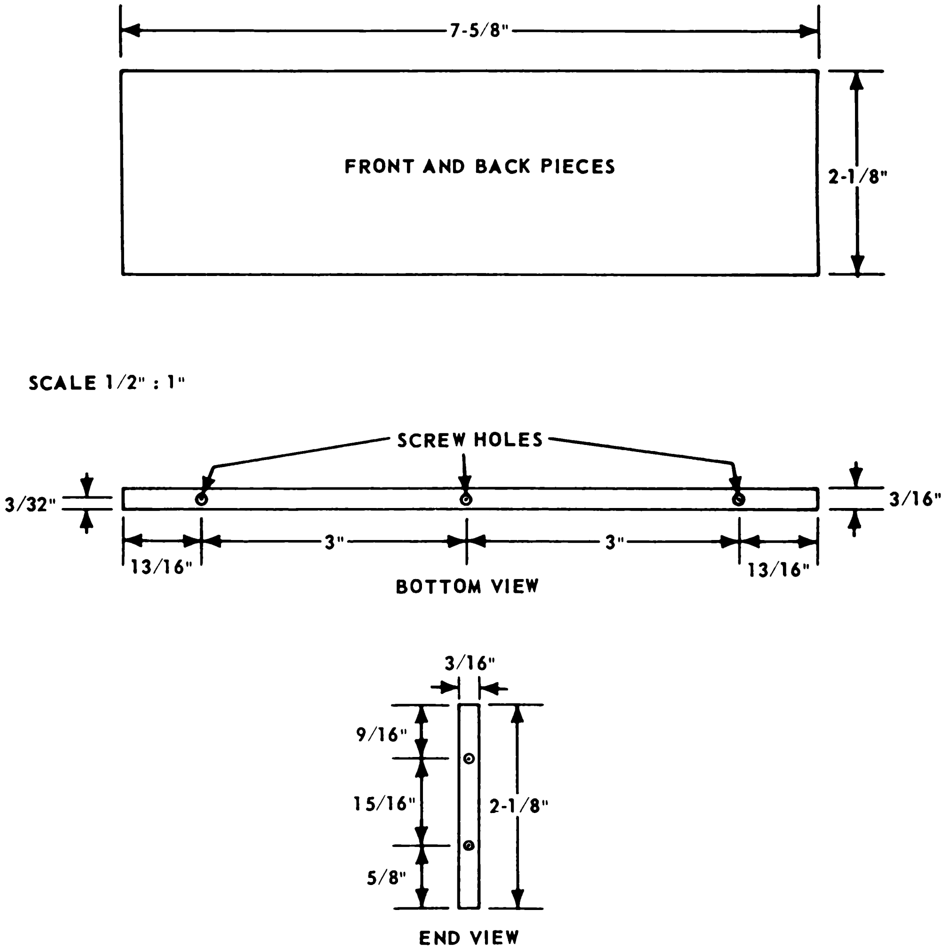
5. Aluminum box, end pieces:

   a. Cut two end pieces, to above specifications, from 3/16" aluminum stock.

   b. Using .089" drill, drill screw holes.

   c. Countersink and tap screw holes to take #4-40, 1/2", aluminum, flat head screws.

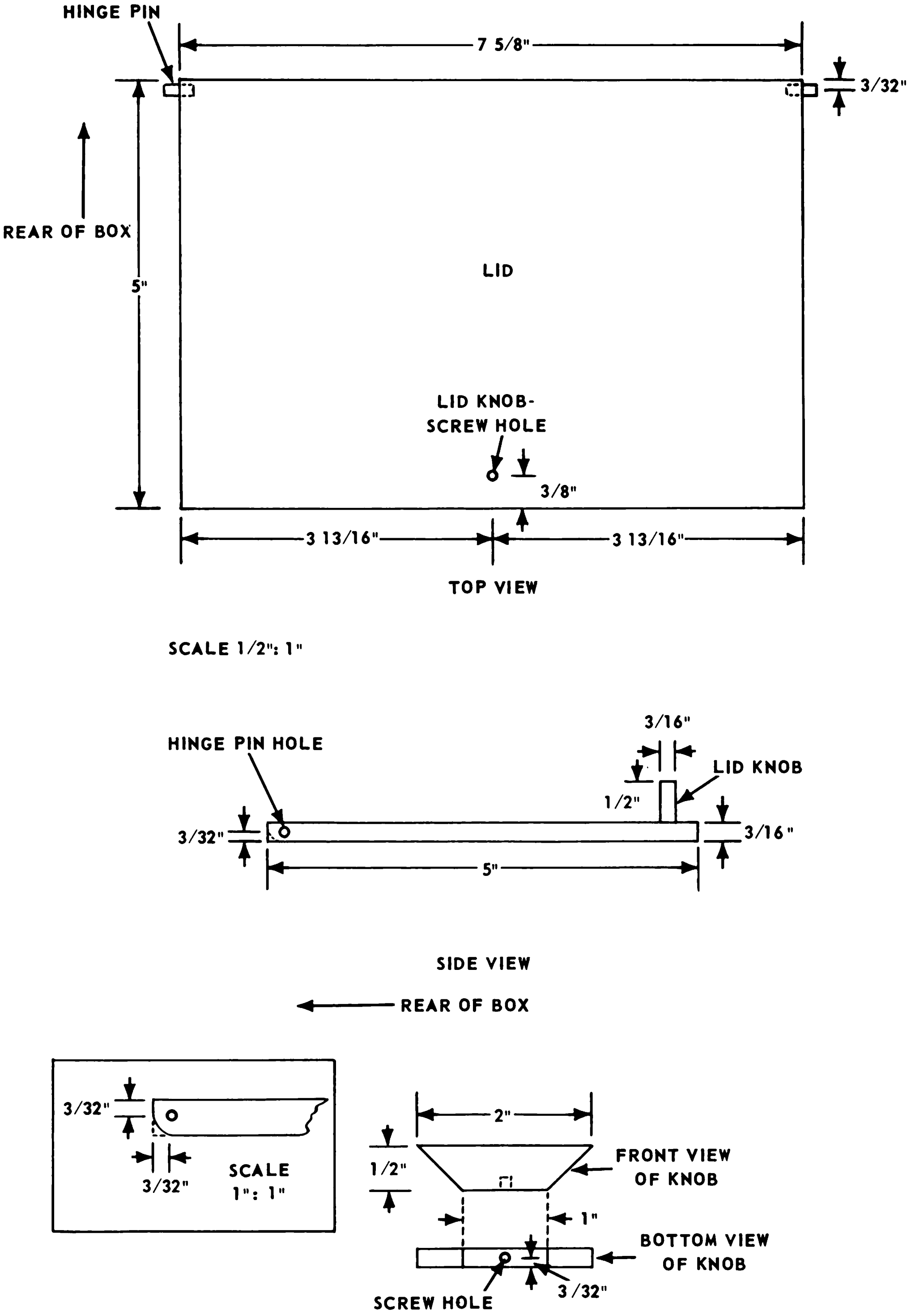
   d. Using #47 drill, drill .078" hinge-pin holes.



4-23. ALUMINUM BOX, FRONT AND BACK PIECES

6. Aluminum box, front and back pieces:
    - a. Cut front and back pieces, to above specifications, from 3/16" aluminum stock.
    - b. Using .089" drill, drill screw holes.
    - c. Tap screw holes to take #4-40, 1/2", aluminum flat head screws.

7. Aluminum box, lid:
    - a. Cut lid, to specifications, from 3/16" aluminum stock.
    - b. Using #47 drill, drill .078" hinge-pin hole to a depth of 1/4".
    - c. Use #6/0, 1/2" pin for hinge pin.
    - d. Using a file, round off rear lower edge of lid for opening



4-24. ALUMINUM BOX, LID AND KNOB

and closing clearance (see inset on illustration #4-24).

e. Using #43 drill, drill .089" lid knob screw hole.

f. Countersink lid knob screw hole to take a #4, 1/2", self-tapping screw.

8. Aluminum box, lid knob:

   a. Cut lid knob, to specifications, from 3/16" aluminum stock.

   b. Using #43 drill, drill .089" lid knob screw hole to a depth of 7/16".

QUIZ SHEETS:

1. On electric equipment, tools with ________________ handles should be used.

2. When tools have to be sharpened on power grinders, the most important safety precaution to be taken is the use of

   a. Gloves.
   b. Goggles.
   c. Insulated handles.
   d. Safety shoes.

3. Which type of pliers is suited best for cutting and removing cotter pins?

   ____

   ____

4. Holes in metal are started with a/an

   a. Starting punch.
   b. Pin punch.
   c. Center punch.
   d. Aligning punch.

5. Which type of metal is used to make the strongest wrenches?

   ____

   ____

6. Which instrument or tool must be used in conjunction with calipers, to obtain accurate measurements?

   ____

7. One complete revolution of the thimble on a micrometer equals __________ inch(es).

8. Micrometers may be adjusted to compensate for wear.

   True _______ or False _____.

9. The teeth of a hacksaw blade should be pointed

   a. Toward the handle.
   b. Away from the handle.

10. Pressure should always be applied to the hacksaw during the back stroke.

    True _______ or False _____.

11. Files are designed to cut only on the forward stroke.

    True ______ or False _____.

12. The angle from the centerline of a twist drill to the cutting lip should be

    a. 59°.
    b. 12°.
    c. 15°.
    d. 45°.

13. Of which kind of material must twist drills be made for drilling armor plate?

    a. Carbon steel.
    b. Alloy steel.
    c. Stainless steel.
    d. Chromed steel.

14. Reamers are used to smooth and to enlarge holes to the exact size required.
    True ______ or False _____.

15. Taps are used for cutting external threads.

True ______ or False ______.

16. Soft solder is composed of:

a. 50% zinc and 50% tin.
b. 50% copper and 50% lead.
c. 50% lead and 50% zinc.
d. 50% tin and 50% lead.

17. Electrical connections should be soldered by using a flux composed of:

a. Acid.
b. Zinc chloride.
c. Rosin.
d. Stearine.

18. The process of coating a copper soldering iron with solder, to prevent oxidation of the iron when it is heated, is called:

a. Fluxing.
b. Tinning.
c. Oxidizing.
d. Acid treatment.

19. When installing tubing, always use straight lengths of tubes, where possible.

True ______ or False ______.

20. Dowel pins usually have a taper of 1/4" per foot.

True ______ or False ______.

21. How many threads per inch has a 6-32 machine-screw?

a. 6.
b. 32.
c. 26.
d. 38.

22. The points of type Z metal screws are:

a. Sharp.
b. Round.
c. Blunt.
d. Coned.

23. Carriage bolts have short square shanks under their heads.

True ______ or False ______.

24. Which type of oil stone is best suited for sharpening cutting tools?

a. Natural stone.
b. Rotten stone.
c. Silicon carbide.
d. Aluminum oxide.

25. Garnet-coated cloth sheets are used to sand metal objects.

True ______ or False ______.

Accuracy of notes checked by instructor:

Trainee's initials ________________________

Date ______________________________________

Section 5

MATHEMATICS REVIEW

ASSIGNMENTS

Topic No.	Topic Title	Page
1.	Arithmetic	See page 140
2.	Elementary Algebra	See page 140
3.	Graphic Representation and Analysis	See page 140
4.	Vector Analysis	See page 140

TOPICS 1 THROUGH 4 OF SECTION 5

You Are Now Going To Learn:

Refer to appropriate section of NavPers 92662, Section 6, Topics 1 through 4.

You Will Acquire Skill In:

Refer to appropriate section of NavPers 92662, Section 6, Topics 1 through 4.

Discussion Points For This Section Are:

1. Arithmetic.
2. Elementary algebra.
3. Graphic representation and analysis.
4. Vector analysis.

ASSIGNMENT:

A. Reference publication:

1. Study NavPers 92662, Vol. II, Section 6, Topic 1.
2. Study NavPers 92662, Vol. II, Section 6, Topic 2.
3. Study NavPers 92662, Vol. II, Section 6, Topic 3.
4. Study NavPers 92662, Vol. II, Section 6, Topic 4.

INFORMATION AND DISCUSSION:

The discussion points for Section 5, Topics 1 through 4, are thoroughly covered in the assignments. Study the text carefully and in proper sequence.

Section 6

POSITIONING MECHANISMS

ASSIGNMENT-DISCUSSION-QUIZ SHEETS

Topic No.	Topic Title	Page
1.	Gears and Gear Trains	142
2.	Cams	152
3.	Differentials	158
4.	Linkages and Couplings	160

TOPIC 1: GEARS AND GEAR TRAINS

You Are Now Going To Learn:

1. Definitions, uses, characteristics, and types of gears and gear trains.
2. Operational principles of gear trains.

Discussion Points For This Topic Are:

1. Definitions of gears.
2. Uses of gears and gear trains.
3. Characteristics of gears and gear trains.
4. Types of gears and their uses.
5. Operations of gear trains.
6. Review and summary.

ASSIGNMENT:

A. Reference publications:

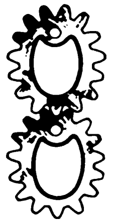
1. Study NavPers 10181, pages 39 through 54.
2. Study NavPers 10624, pages 67 through 76.

INFORMATION AND DISCUSSION:

When two or more shafts are not located in the same straight line, but are parallel or perpendicular to each other, motion can be transmitted from one shaft to another by means of gears.

Gears are wheels with teeth cut into their surfaces. The teeth may be either internal or external; their cut or angle may vary.

Gears may have various outlines; usually they are round, but may also be elliptical or eccentric (irregular).



6-1. ELLIPTICAL OR ECCENTRIC GEARS

A combination of two or more gears is called a gear train.

If two meshing gears are of the same size, they also have the same number of teeth. The teeth of the one gear are machined to match the teeth of the other gear, so that one gear can turn the other without slippage. One revolution of the driving gear rotates the driven gear also one revolution, because each tooth of the driving gear pushes a corresponding tooth of the driven gear.

Gears are also used to change

the direction of motion; for instance, rotary motion can be changed to straight-line or up-and-down motion.

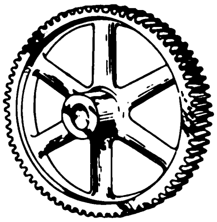
In addition, gears can be used to reduce or increase the rate of motion or torque.

Depending on the purpose, various types of gears can be used, for instance, spur gears, helical gears, or bevel gears.

Gears are generally made of hardened metal; however, if quiet operation at high speed is essential and if the gears are not subjected to severe strain, nonmetallic gears can be used. The latter may be made of formica (a laminated insulating material) or of some other kind of plastic.

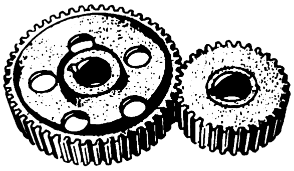
Where gears are subjected to friction, a driver gear made of leather or fiber and a driven gear of metal are used. The result is a smooth but not powerful drive.

The most commonly used types of gears are spur gears. They are used to connect parallel shafts. The teeth of spur gears are cut parallel to the axis of gear rotation.



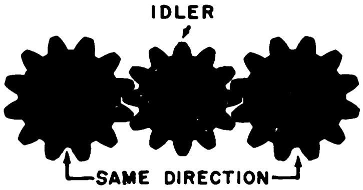
6-2. SPUR GEAR

When two external gears mesh, they rotate in opposite directions. (The most common type of external spur gears is shown in the following illustration.)



6-3. EXTERNAL SPUR GEARS

To rotate two spur gears in the same direction, an idler gear is placed between them. The idler gear does not change the gear ratio or speed of rotation; it merely changes the direction of motion. (Both, the driver gear and driven gear, rotate in the same direction.)

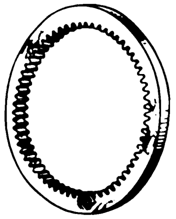


6-4. IDLER GEAR

If two gears are different in size, the smaller one is usually called a pinion. When gear and pinion mesh, their shafts rotate at different speeds; for instance, the shaft of the pinion (driver gear) may complete one revolution, while the shaft of the driven gear completes one-half revolution.

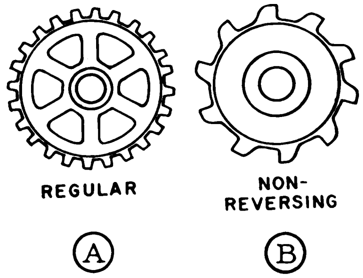
The ratio between the number of teeth on the driver gear and the number of teeth on the driven gear is called the gear ratio. The gear ratio can be established by counting the teeth on the gears.

An internal spur gear has teeth on its inner surface. Usually, an internal spur gear is meshed with an external spur gear. The rotation of the pinion causes the driven gear to rotate in the same direction as the pinion rotates.



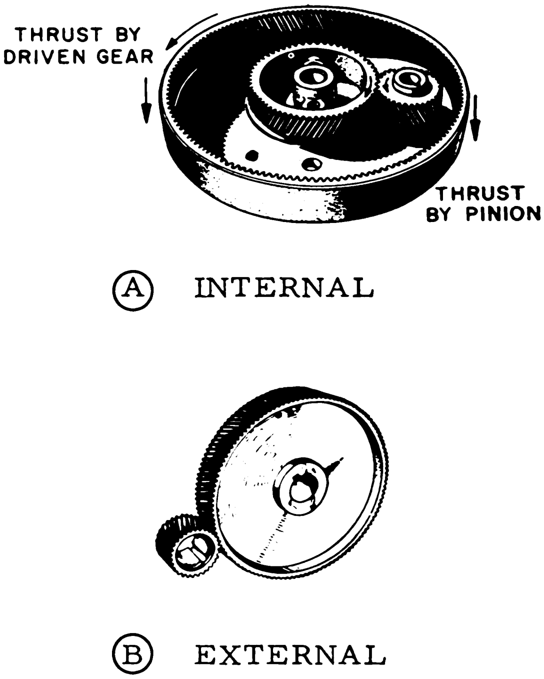
6-5. INTERNAL SPUR GEAR

Sprocket gears are toothed wheels used for driving chains. Sprocket gears may have regular (spur-type) or nonreversing (hook-type) teeth. The hook-type teeth permit rotation in one direction only.



6-6. SPROCKET GEARS

Helical spur gears are used where smooth operation is required. The teeth of helical gears are cut at an angle across the face of the wheel and provide a more constant pull than regular spur gears.

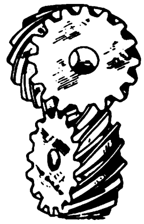


6-7. HELICAL GEARS

NOTE: Since the driven gear of spur gears meshes with the two teeth of the driver gear only at certain intervals, the resulting motion is actually a series of sharp jerks.

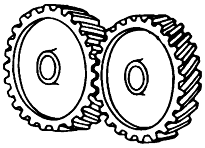
On helical gears, the curves of the teeth enable the succeeding teeth to start meshing before the preceding teeth are unmeshed.

Helical gears are also called skews or spiral gears, although they actually are not absolutely spiral. (Spiral gears are shown in illustration #6-8 on the following page.)



6-8. SPIRAL GEARS

When helical spur gears are used to connect parallel shafts, they may also be called twisted spur gears.

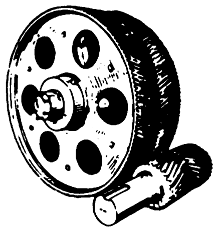


6-9. TWISTED SPUR GEARS

A negative feature of helical spur gears is the tendency of each gear to thrust (push) axially against its shaft. To counteract this thrust, special thrust bearings must be installed at the end of the shaft.

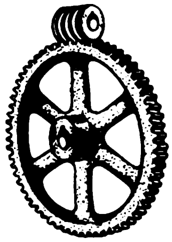
To eliminate the thrust, double helical herringbone gears can be used. They are similar to right-hand and left-hand helical gears placed side-by-side. The teeth of these two gears meet in a chevron-like pattern. The right-hand gear teeth counterbalance the thrust of the left-hand gear teeth or vice versa. As a result, the thrust is eliminated.

Herringbone gears are used on parallel shafts of heavy machinery, for instance, turbines.

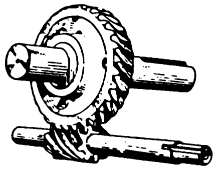


6-10. HERRINGBONE GEARS

Worm gears are used to transmit motion between shafts which are located at right angles to each other. The worm gears may have spur-type or helical type teeth.



Ⓐ SPUR-TYPE TEETH



Ⓑ HELICAL TYPE TEETH

6-11. WORM GEARS

The worm consists of a cylinder with one (single) thread or more (double, triple, etc.) threads which are cut on its outside like the threads of a screw.

The worm-wheel gear has teeth cut on its outside rim. These teeth mesh with the threads on the worm.

Worm gears are used to reduce speed.

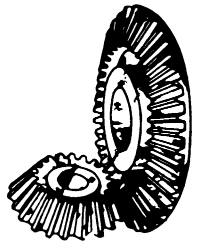
A complete revolution of a single-threaded worm rotates the gear a distance of one tooth; a double threaded worm rotates the gear twice as fast as a single threaded worm.

Worm gears are extremely helpful in performing mechanical work; for instance, a small electrical motor which is connected to worm gearing can drive much heavier equipment than it normally could.

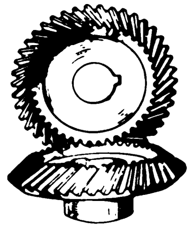
Worm drives are usually constructed so that only the worm is the driver. For example: The worm gear of a deck hoist can raise or lower a load by pulling the chain which rotates the worm. When the chain is released, the load is prevented from dropping on the deck by a nonreversing worm drive; that is, the weight of the load can not drive the worm.

Bevel gears have teeth cut on conical surfaces. These gears are used for transmitting power between shafts which are located at various angles to each other. The gears may have spur-type, skew-type, or helical (spiral) teeth.

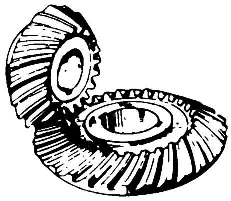
Bevel gears which are of the same size (have the same number of teeth) and whose shafts are located at right angles to each other are called miter gears. (The various applications of miter gears will be discussed in Topic 3 of this section.)



Ⓐ SPUR-TYPE TEETH

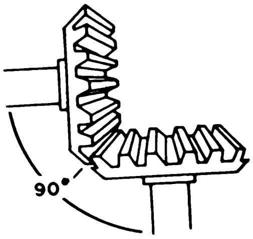


Ⓑ SKEW-TYPE TEETH



Ⓒ HELICAL TEETH

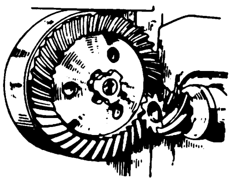
6-12. BEVEL GEARS



6-13. MITER GEARS
(1 : 1 RATIO)

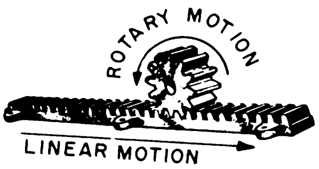
A recent development in bevel gearing is the Zeral-tooth gears or Gleason bevel-gears. The teeth of these gears are curved to provide continuous contact and to avoid concentrated loads on the ends of the teeth in the event of a slight misalignment. The Gleason bevel-gears operate quieter than all other bevel gears.

The hypoid gear is a spiral bevel gear whose pinion is located above or below the center of rotation of the gear.



6-14. HYPOID GEARS

The rack and pinion are devices for converting rotary motion to linear motion or vice versa. The small wheel (pinion) meshes with a toothed rack. Both, the rack and pinion, have usually spur-type teeth.

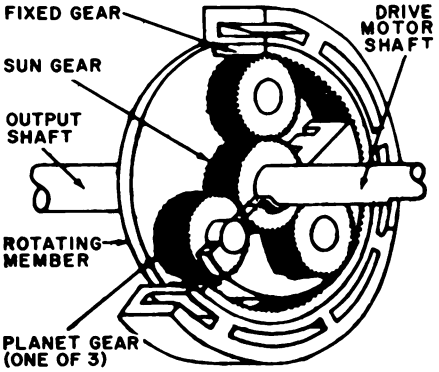


6-15. RACK AND PINION

Planetary gears (also called epicyclic gears) consist of a train of gear wheels. The center (helical) gear is called a sun gear.

In planetary gears, three helical gears (called planet gears), grouped 120 degrees apart, mesh with the sun gear and a large fixed internal gear.

When the drive-motor shaft revolves, it causes the sun gear, which is an integral part of the shaft, to rotate. This motion is transmitted to the planetary gears which, in turn, transmit the motion to the fixed internal gears, producing an output at reduced speed on the output shaft.



6-16. PLANETARY GEARS

The planetary reduction gears are used to reduce the speed of drive motors in hydraulic train and elevation systems. For example, the electric drive motor of a 5"/38 twin mount revolves at approximately

3500 rpm, while the hydraulic pump is designed to rotate only at 900 rpm; therefore, a planetary gear, located between the electric motor and the pump, is used to reduce the speed of the pump to 900 rpm.

Planetary gears are also used in other systems for similar purposes.

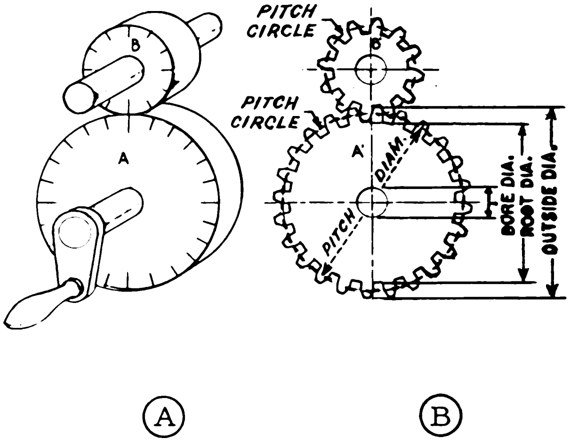
To define the diameter of a gear, it is necessary to specify whether it is an outside diameter, a bore diameter (diameter of hole in gear), root diameter (root-to-root diameter of opposite teeth), or a pitch diameter.

The pitch circle is a line drawn through the pitch point of each gear tooth that represents an imaginary surface which corresponds to the friction surface. The pitch diameter is the diameter of this circle.

In gearing, the pitch diameter is a very important factor, because the relative velocities of the meshing gears depend upon their pitch diameters. (The number of teeth in the pitch circle determines the speed of a gear.)

The part of the tooth located between the outside circle and the pitch circle does not transfer any power; the transfer begins at the pitch point of a gear tooth.

The term "pitch" is used in machinery to denote the distance from one pitch point of a gear tooth to the corresponding pitch point of the next tooth.



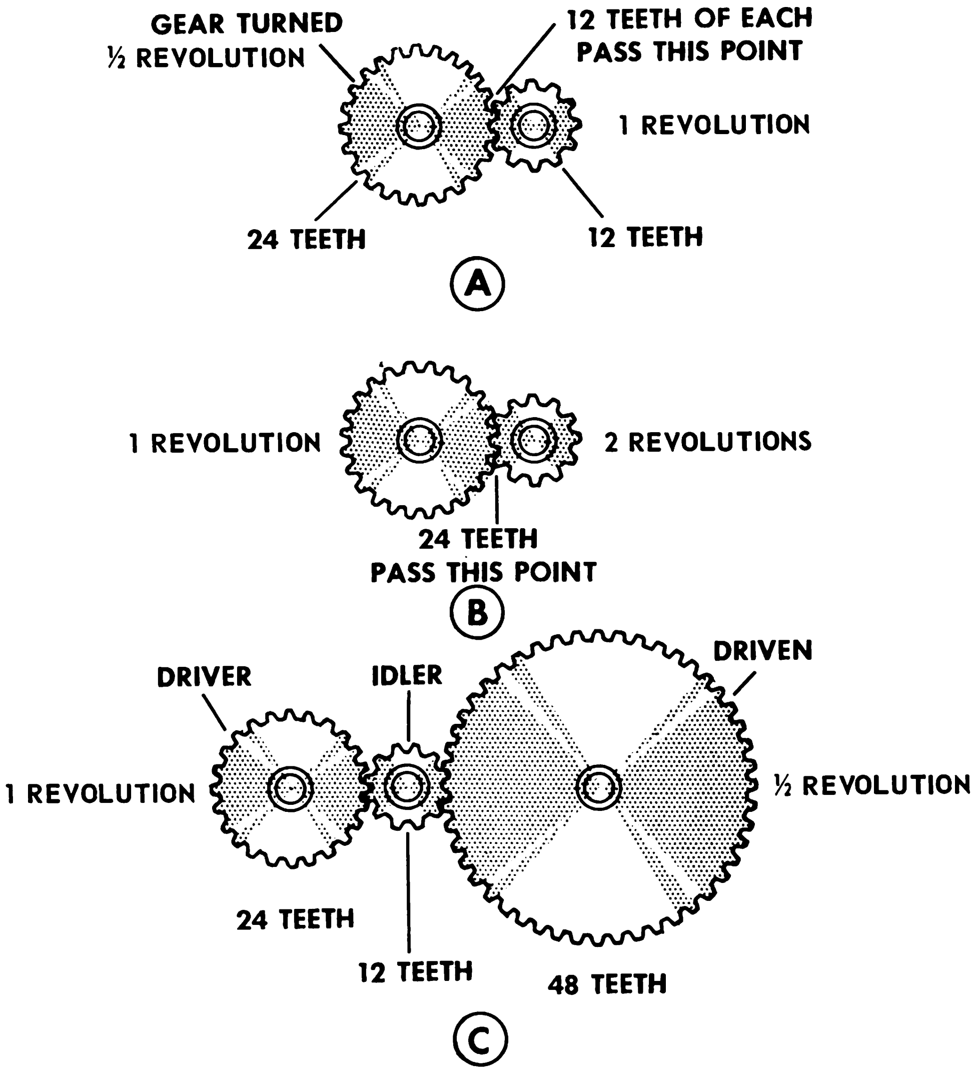
6-17. PITCH MEASUREMENTS OF GEARS

If a gear is defined as a 20-DP or 20-P gear, it has 20 teeth on each inch of its pitch diameter. The letters "DP" stand for diametrical pitch. They also define the size of the gear teeth. For instance, if a gear with a pitch diameter of 2 inches has 40 teeth, it has 20 teeth per inch of pitch diameter or 20 DP. A gear of the same pitch diameter (2 inches) with a total of 20 teeth would be defined as a 10-DP gear. The teeth of the 10-DP gear would, of course, be larger and heavier than those of the 20-DP gear. (Two meshing gears must have the same diametrical pitch.)

NOTE: When internal and idler gears are used, the driver and driven gears always move in the same direction. To reverse direction, two external gears are used. Bevel or spiral gears are used when gear shafts are located at angles to each other. Various combinations can be acquired through gear trains.

As already mentioned at the beginning of this topic, gears are also used to change the speed of motion. For instance, if a 24-tooth gear is meshed with a 12-tooth gear (pinion), the 24-tooth (driver gear) makes one revolution, while the 12-tooth gear (driven gear) makes two, thus producing a speed increase at a 1 : 2 ratio. If the 12-tooth gear is the driver, the ratio is reversed and the speed reduced; but there is a gain in force, since the input gear now makes two revolutions while the output gear makes one.

When an idler gear is placed between the driver gear and the driven



6-18. GEAR RATIOS

gear, the gear ratio of the driven gear shown in illustration #6-18 (C) on the preceding page can be found by using the following formula:

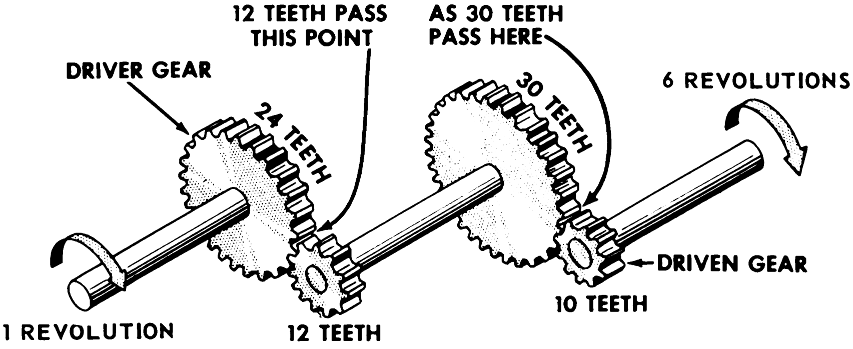
24/12 x 12/48 = 1/2

However, to step up six times the speed of an output shaft which has a 10-tooth gear, a driver gear with 60 teeth would be required which would be rather complicated; therefore, a gear train is used to achieve the same result in an easier way as shown in the following illustration.

The 24-tooth gear meshes with the 12-tooth gear and causes it to rotate twice as fast as the input gear. The 12-tooth gear, in turn, rotates the 30-tooth gear at the same speed. The 30-tooth gear is meshed with a 10-tooth gear. The 30-tooth gear is now the driver and causes the 10-tooth gear to rotate at three times the speed of the driven gear.

The resultant ratio is:

24/12 x 30/10 = 6/1



$$\frac{24}{12} \times \frac{30}{10} = \frac{6}{1}$$

6-19. STEP-UP GEAR TRAIN

TOPIC 2: CAMS

You Are Now Going To Learn:

1. Purpose, construction features, and classification of cams.
2. Application of cams in ordnance equipment.

Discussion Points For This Topic Are:

1. Purpose of cams.
2. Classification of cams.
3. Construction features of various types of cams.
4. Special cams.
5. Application of cams in ordnance equipment.
6. Review and summary.

ASSIGNMENT:

A. Reference publications:

1. Study NavPers 10181, pages 55 through 59.
2. Optional reading list:
   a. OP 1140, pages 46 through 59.

INFORMATION AND DISCUSSION:

Cams are mechanisms that normally contain a curved path or surface (either groove, ridge, or contour) and are used to convert rotary motion to linear motion.

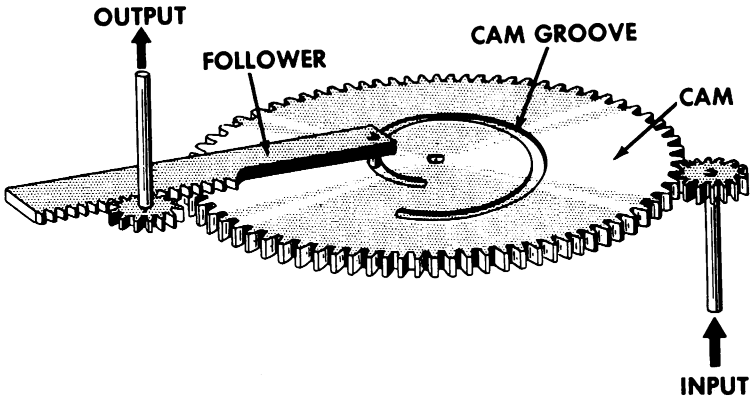
All cams have a follower (a roller, ball, or pin) which bears against the curved surface or follows the path of the cam. As the cam rotates, the follower is pushed or pulled by the curved surface or path in a position which represents the output value for the contact point of the cam.

Cams are ordinarily not used for transmitting power as, for instance, gear trains are; normally cams are used to modify mechanical movements, to control other mechanisms, or to synchronize engaging units.

A cam can be a simple device used to trip a switch or can be a complicated mechanism capable of computing the tangent, square, or reciprocal of the input.

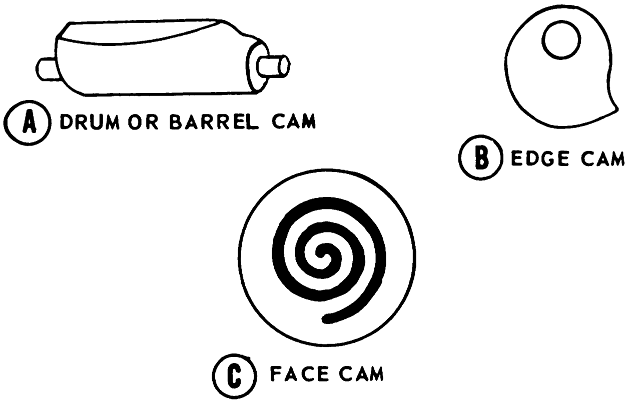
In illustration #6-20 on the following page, a rack and pinion are shown which are used to convert the linear cam output to a rotary motion. However, not all cams are like the one shown in this illustration: Some cams are just a projection of a shaft or a wheel; others do not move, but are contacted by a mechanical lever, arm, or actuator.

Technical manuals disagree on how to classify the various types of



6-20. TYPICAL CAM WITH ASSOCIATED LINKAGE

cams, since they may either be grouped by their functions or by shapes. In the following illustration, the cams are classified by shape.

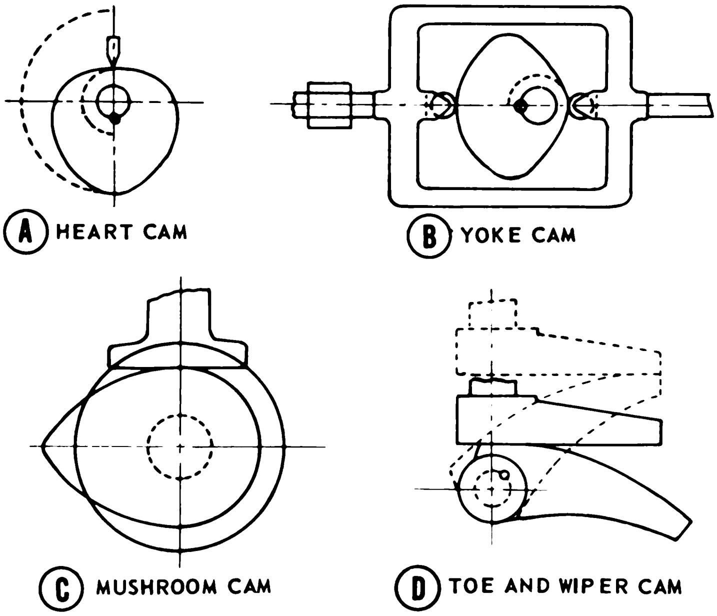


6-21. CLASSIFICATION OF CAMS BY SHAPE

The drum (barrel) cam shown in the above illustration requires two inputs: One to rotate the cam (barrel), the other to move the follower laterally. The output of this cam is in a plane perpendicular to the axis of the cam. The drum cam is also called a three-dimensional or ballistic cam. It is used mainly in fire control equipment.

There is another type of drum (barrel) cam which has a path for the roller (or follower) cut around its contour. The output of this cam is parallel to the axis of the cam. This type of cam requires only one input.

The edge cam shown in illustration #6-21 is the most common type of cam. The edge cam is available in various shapes and sizes. The follower of this cam maintains contact with the outer edge of the cam by force of gravity or by spring action. When the cam is rotated, the follower moves either laterally toward or away from the axis of cam rotation. (Illustration #6-22 on the following page shows various types of edge cams.)



6-22. TYPES OF EDGE CAMS

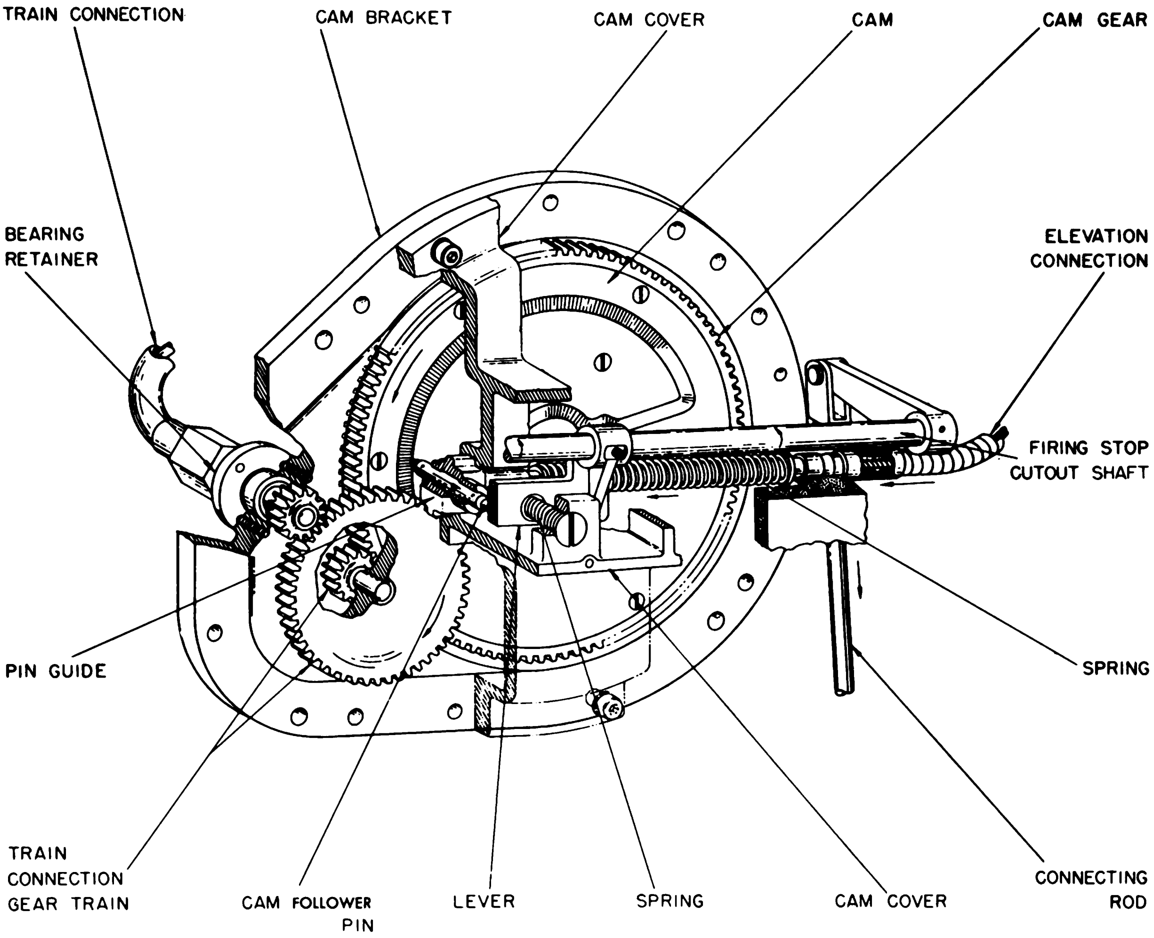
A face cam may have a groove or roll path cut into its face. When the cam rotates, the groove forces the follower either away from or toward the center of the cam.

The spiral-groove face cams have frequently "run-out" sections at each end of cam movement. The "run-out" section has a constant radius; therefore when the follower is in this cam section, there is no output.

The plate (profile) cam, which is another type of face cam, has a section of the cam face cut away, leaving high and low areas. This type of cam usually has two inputs: one for positioning the cam, the other for positioning the follower. When the follower rides from a high to a low section of the cam or vice versa, the follower actuates the output linkage and/or a switch to register the output.

In ordnance equipment, many special types of cams are used to accelerate, decelerate, time, and stop the power devices. The special cams are also physically contacted by the moving power equipment to actuate the mechanical linkages, switches, and valves. The majority of these special cams can be classified as drum, edge, or face cams.

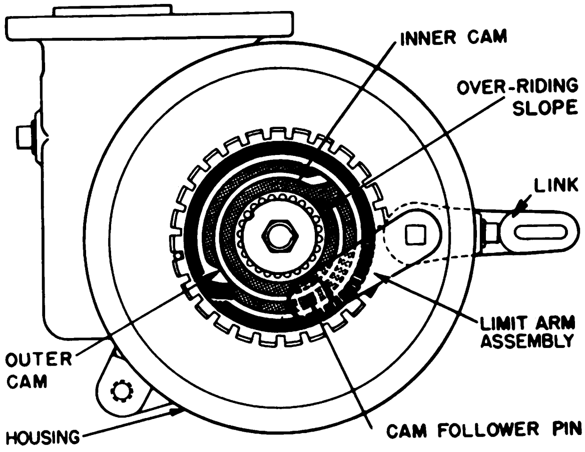
Cams find application in all naval guns, launchers, and projectors. They are used to prevent own ship's weapons from firing into own ship's structure. In many guns profile face-cams are used for this purpose. A profile (plate) face-cam and its associated linkage used in the 40mm firing stop mechanism is shown in illustration #6-23 on the following page.



6-23. PROFILE FACE-CAM

NOTE: In the 3"/70 gun mounts and missile launcher, a different type of cam is used to perform the same functions. Firing stop mechanisms are also called cutout and firing interrupter mechanisms.

Plate cams with spiral grooves are used on 40 mm guns, Mk 15 projectors, and Mk 108 rocket launchers, to prevent them during power operation from training through a positive stop.



6-24. POWER DRIVE LIMIT STOP CAM

Edge cams are used in all guns and missile launching systems. For instance, in breech mechanisms of 5''/38, 3''/50, and 40 mm guns, edge cams are used to open the breech after firing; in typical missile launcher power drives, approximately ten edge cams are used to actuate the switches.

TOPIC 3: DIFFERENTIALS

You Are Now Going To Learn:

1. The definitions, types, and uses of mechanical differentials.
2. The operational characteristics of mechanical differentials.

Discussion Points For This Topic Are:

1. Definitions of mechanical differentials.
2. Characteristics of mechanical differentials.
3. Types of mechanical differentials and their uses.
4. Mechanical differential symbols.
5. Review and summary.

ASSIGNMENT:

A. Reference publications:

   1. Study NavPers 92662, Volume I, Section 1, Topic 21.
   2. Study OP 1140, pages 40 through 45.
   3. Study NavPers 10173, pages 58 through 62.

INFORMATION AND DISCUSSION:

The discussion points listed in this topic are thoroughly covered in the assignment.

TOPIC 4: LINKAGES AND COUPLINGS

You Are Now Going To Learn:

1. Purpose and types of linkages and couplings.
2. Application of linkages and couplings in ordnance equipment.

Discussion Points For This Topic Are:

1. Basic parts, purpose, and adjustments of linkages.
2. Types and uses of couplings and universal joints.
3. Review and summary.
4. Section review.
5. Written test.

ASSIGNMENT:

A. Reference publication:

   1. Study NavPers 10181, page 60, and pages 74 through 76.

INFORMATION AND DISCUSSION:

A linkage may consist of either one or a combination of the following basic parts:

1. Rod, shaft, or plunger.
2. Lever.
3. Rocker arm.
4. Bell crank.

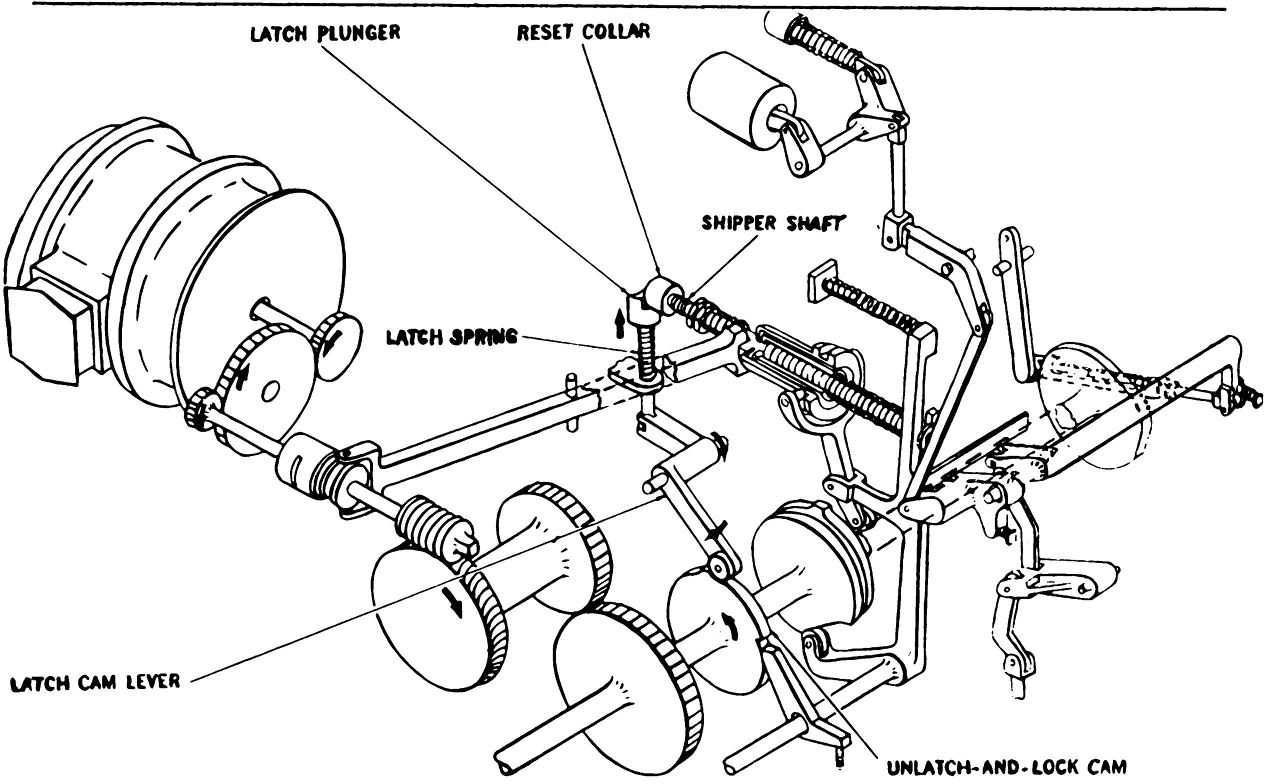
These parts combined are used to transmit limited rotary or linear motion. To change the direction of motion, cams or gears may be used with the linkage.

In a unit of ordnance equipment, linkage may be used for several purposes. (Refer to illustration #6-25 on the following page.)

Lever-type linkages are used in equipment which has to be opened and closed; for instance, valves in electric-hydraulic systems, gates, clutches, clutch-solenoid interlocks, etc.

All linkages require occasional adjustments or repair, particularly when they become worn. To make the proper adjustments, a person must be familiar with the basic parts which constitute a linkage. Adjustments are normally made by lengthening or shortening the rods and shafts by means of a clevis or turnbuckle.

The term "coupling" (in a broad sense) applies to any device that holds two parts together. Line



6-25. LINKAGES

shafts which are made up of several shafts of different lengths may be held together by shaft couplings of several types.

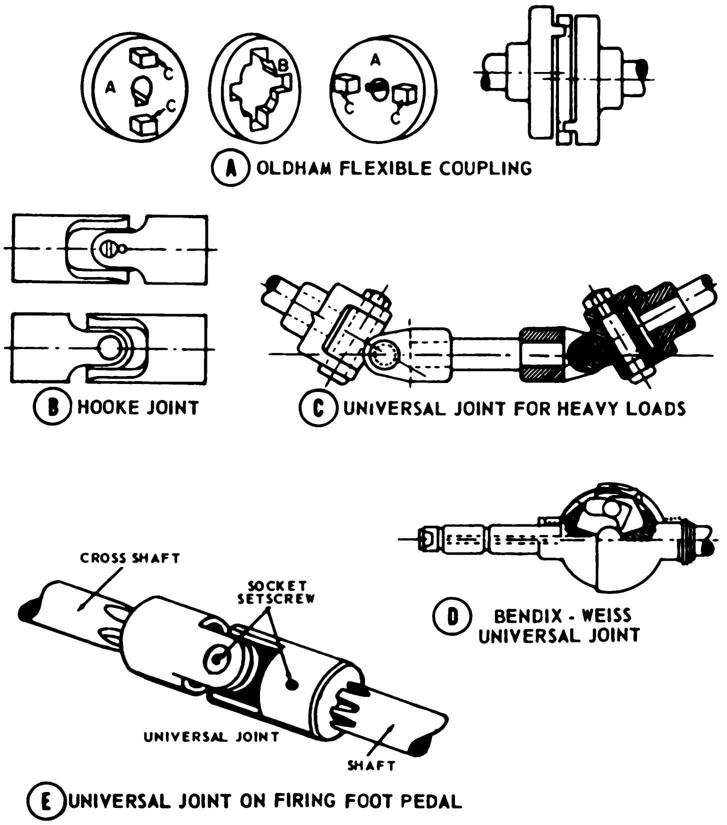
A universal joint is a coupling between two nonparallel intersecting shafts, which transmits the rotation of one shaft to the other shaft.

Universal joints may have various forms and may be used in various combinations. They find important application in naval ordnance.

An elementary universal joint, also called Cardan joint (after the Italian who was the first one to describe it) or a Hooke joint (after the Englishman who was the first one to use it), consists of two U-shaped yokes fastened to the ends of the shafts to be connected. Within these yokes there is a cross-shaped part which holds the yokes together.

A combination of two Hooke joints is shown in illustration #6-26 (B) on the following page. When Hooke joints are used, the driver shaft and the driven shaft are joined by an intermediate shaft. All shafts are located on the same plane, and the coupling pins are parallel to each other. This type of joint is used in the Vicker's axial-piston pump.

The Bendix-Weiss joint, shown in illustration #6-26 (D) on the following page, is designed to maintain constant velocity of shaft



(A) OLDHAM FLEXIBLE COUPLING

(B) HOOKE JOINT

(C) UNIVERSAL JOINT FOR HEAVY LOADS

(D) BENDIX - WEISS UNIVERSAL JOINT

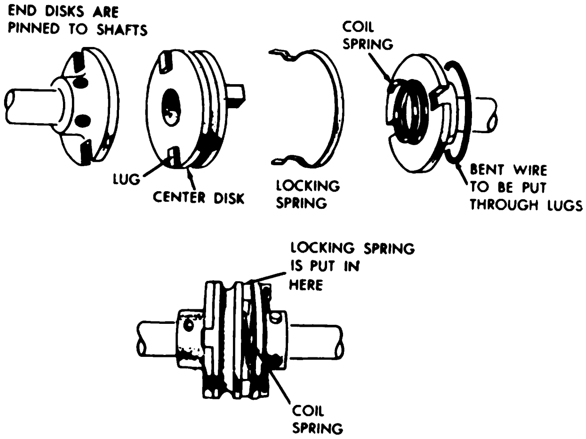
(E) UNIVERSAL JOINT ON FIRING FOOT PEDAL

6-26. TYPES OF UNIVERSAL JOINTS

rotation, regardless of the angle of the shafts. The Bendix-Weiss joint is used in the A-ends of train and elevation power drives on many 5"/38 single mounts.

An Oldham coupling consists of a pair of disks of which one is flat and the other hollow. These disks are pinned to the ends of the shafts. A third (center) disk, with a pair of lugs projecting from each face of the disk, fits into the slots between the two end-disks and thus enables one shaft to drive the other shaft. A coil-spring, housed within the center and the hollow end-disk, forces the center disk against the flat disk. When the coupling is assembled on the shaft ends, a flat lock-spring is slipped into the space around the coil-spring. The ends of the flat spring are formed so that when the flat spring is pushed into the proper place, the ends of the spring are pushed out and locked around the lugs. A lock wire is passed between the holes drilled through the projecting lugs to guard the assembly. The coil spring compensates for any change in shaft length. (Shaft length may vary due to changes in temperature.)

Oldham couplings have one important feature: They can be easily


END DISKS ARE PINNED TO SHAFTS
COIL SPRING
LUG
CENTER DISK
LOCKING SPRING
BENT WIRE TO BE PUT THROUGH LUGS
LOCKING SPRING IS PUT IN HERE
COIL SPRING

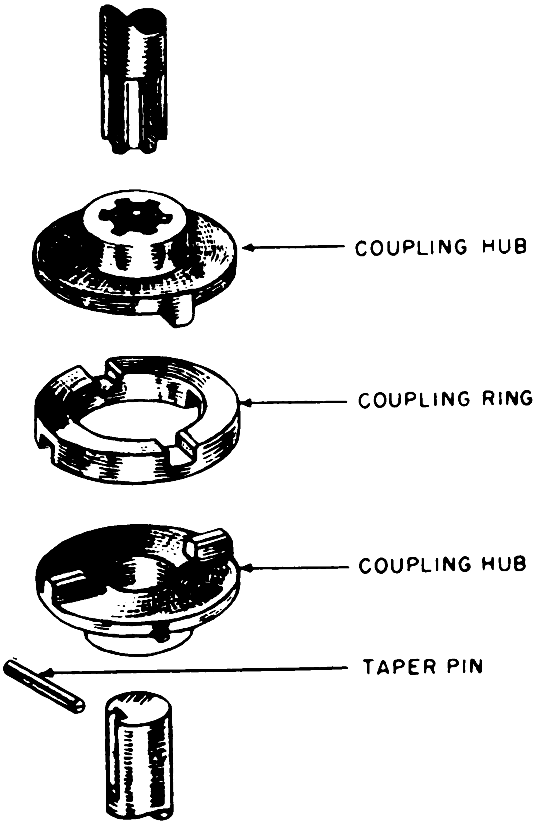
6-27. OLDHAM COUPLING

connected or disconnected. Oldham couplings are used to join shafts which do not require perfect alignment. They are also used between the pump and the electric motor in the rammers of 5"/38 gun mounts.

The following four types of couplings are used quite extensively in ordnance equipment, for example, in the 5"/38 gun sight system.

1. The fixed (sliding lug) coupling is nonadjustable; however, it does allow for a small amount of misalignment in shafting.

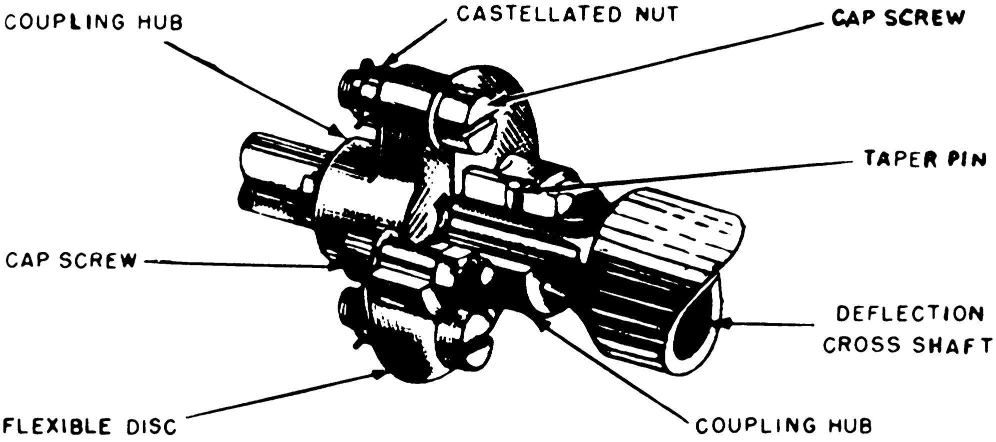
2. The flexible coupling connects two shafts by means of a metal disk. Two coupling hubs, each splined to its respective shaft, are bolted to the metal disk. The flexible coupling provides a small



6-28. FIXED COUPLING

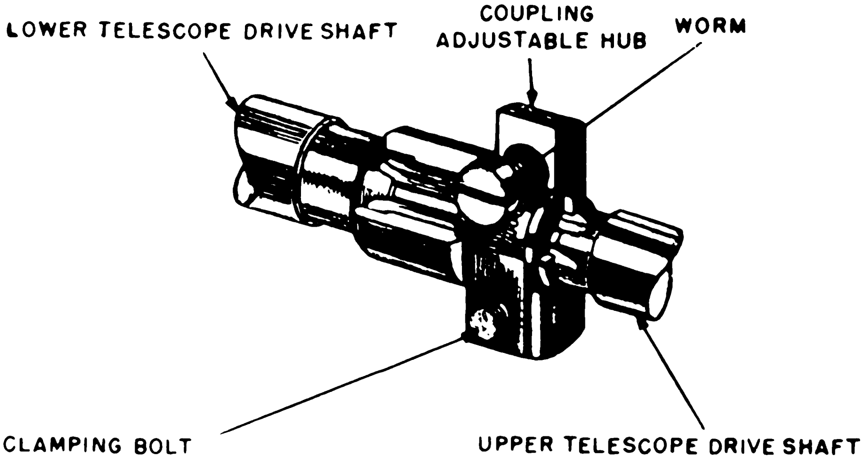
amount of flexibility to allow for a slight axial misalignment of the shafts.

4. The adjustable flexible (vernier) coupling joins the metal disk of the flexible coupling with the adjustable element of the adjustable coupling. Several types of the adjustable flexible coupling are used in the shafting of the 5"/38 gun sight system. (See illustration on following page.)

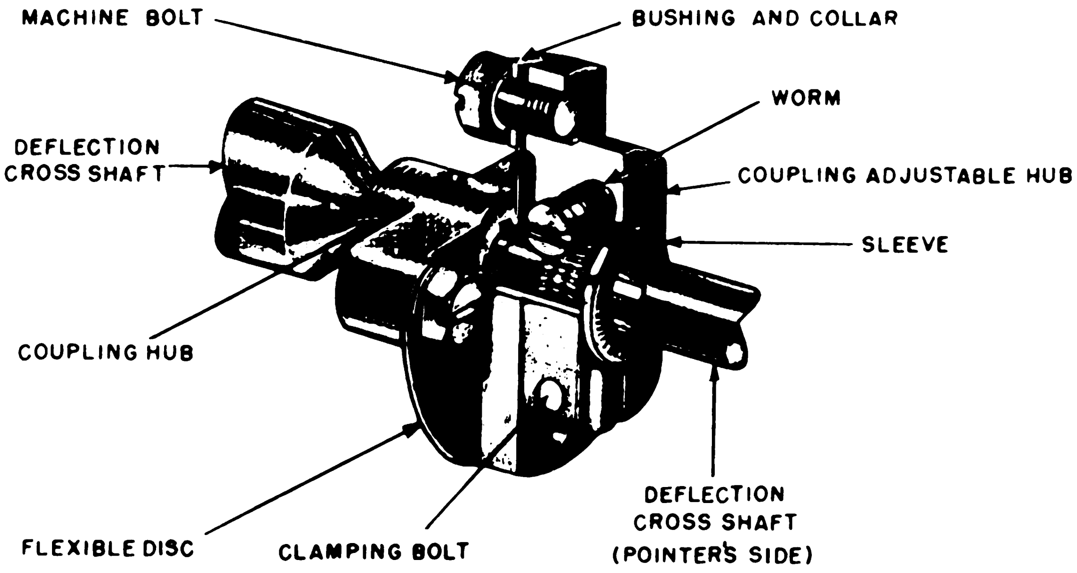


6-29. FLEXIBLE COUPLING

3. The adjustable (vernier) coupling provides a means of rotating the shaft so that the optics are in correspondence with the sight-dial indication and the gun position.



6-30. ADJUSTABLE COUPLING



6-31. ADJUSTABLE FLEXIBLE COUPLING

QUIZ SHEETS:

1. To connect shafts at a 90° angle to each other, the following type of gears is used:

   a. Elliptical.
   b. Spur.
   c. Worm.
   d. Helical.

2. The gear used to rotate the driver and driven gear in the same direction is called:

   a. Spiral.
   b. Miter.
   c. Rack and pinion.
   d. Idler.

3. The driver gear and driven gear of an internal pinion gear rotate in opposite directions.

   True ______ or False ______.

4. What is the gear ratio between a 30-tooth driver gear and a 10-tooth driven gear?

   a. 3 : 1.
   b. 1 : 3.
   c. 30 : 10.
   d. 10 : 3.

5. Bevel gears are used to connect shafts at a 30° angle.

   True ______ or False ______.

6. The gear speed depends on the number of teeth in the pitch circle.

   True ______ or False ______.

7. The main purpose of cams is to change

   a. Linear motion to rotary motion.
   b. Lateral motion to circular motion.
   c. Rotary motion to linear motion.
   d. Circular motion to rotary motion.

8. The outer edge of the plate of a face cam is elliptical.

   True ______ or False ______.

9. The type of cam used to open the breech mechanism after firing of a 40mm gun is called

   a. Profile.
   b. Face.
   c. Edge.
   d. Barrel.

10. If both end gears of a differential are rotated in opposite directions at the same speed, the output on the spider is equal to

    a. One-quarter output of both end gears.
    b. One-half output of both end gears.
    c. Zero.
    d. The sum of the outputs of both end gears.

11. If the spider of a differential is held, the output ratio of one end-gear to the other end-gear is 1 : 1, and both gears rotate in opposite directions.

True ______ or False ______.

12. The operation of a mechanical pencil is similar to the operation of one of the following differentials:

a. Spur-type.
b. Bevel-type.
c. Screw-type.
d. Barrel-type.

13. To adjust linkage, a clevis or turnbuckle is normally used.

True ______ or False ______.

14. A universal joint is used for coupling two parallel shafts.

True ______ or False ______.

15. To maintain constant velocity of shafts regardless of their angle, one of the following devices is used:

a. Fixed coupling.
b. Flexible coupling.
c. Bendix-Weiss joint.
d. Oldham coupling.

Accuracy of notes checked by instructor:

Date ______________________________

Trainee's initials ____________________

Section 7

WEAPON SYSTEM HYDRAULICS

ASSIGNMENTS-DISCUSSION

Topic No.	Topic Title	Page
1.	Glossary of Commonly Used Hydraulic Terms . .	172
2. through 20., 22., and 23.	See NavPers 92662, Vol. I	See page 184

TOPIC 1: GLOSSARY OF COMMONLY USED HYDRAULIC TERMS

You Are Now Going To Learn:

1. Hydraulic terms commonly used in the Navy.

Discussion Points For This Topic Are:

1. Introduction to the hydraulic glossary.

2. Glossary of common hydraulic terms.

ASSIGNMENT:

A. Reference publications:

   1. Optional reading list:

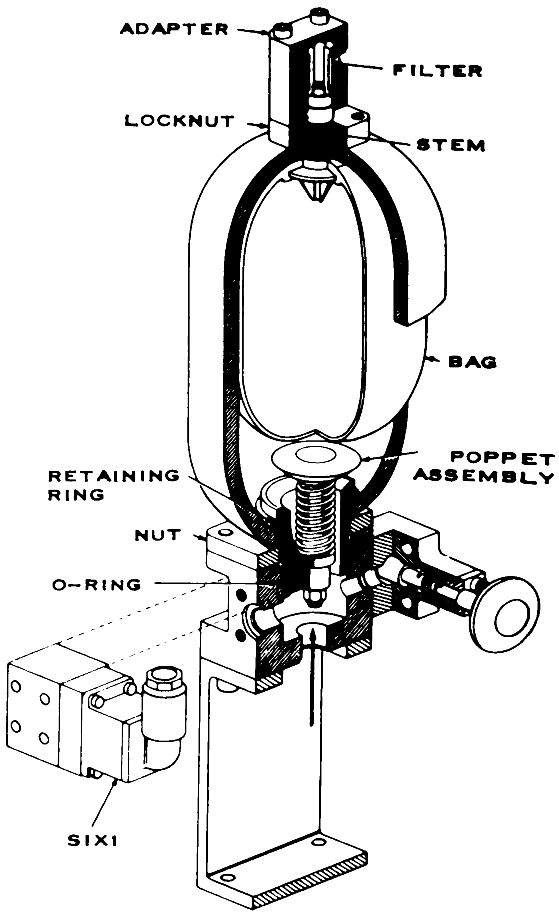
      a. NavPers 16193, Basic Hydraulics.
      b. NavPers 10184, Gunner's Mate 2, Chapters 4 and 5.
      c. Pippenger & Koff: Fluid Power Controls.

INFORMATION AND DISCUSSION:

The following list of hydraulic terms, abbreviations, and definitions is included in this topic both as an introduction to hydraulics and as a reference for the remainder of the section. These terms may often have more than one meaning; however, only the definition which applies to a hydraulic system will be discussed in this topic.

GLOSSARY

ACCUMULATOR: Device for storing hydraulic fluid under pressure. Accumulators function to (1) store power to allow system to meet short demands in excess of pump output, (2) smooth out surges and pulsations, and (3) meet low-capacity demands without operation of high-capacity pump (except intermittently to charge accumulator).



7-1. BAG-TYPE ACCUMULATOR

A-END: Variable delivery pump. Normally driven by a constant-speed electric motor, provides continuously variable control of speed and direction of output. (Refer to illustration #7-4.)

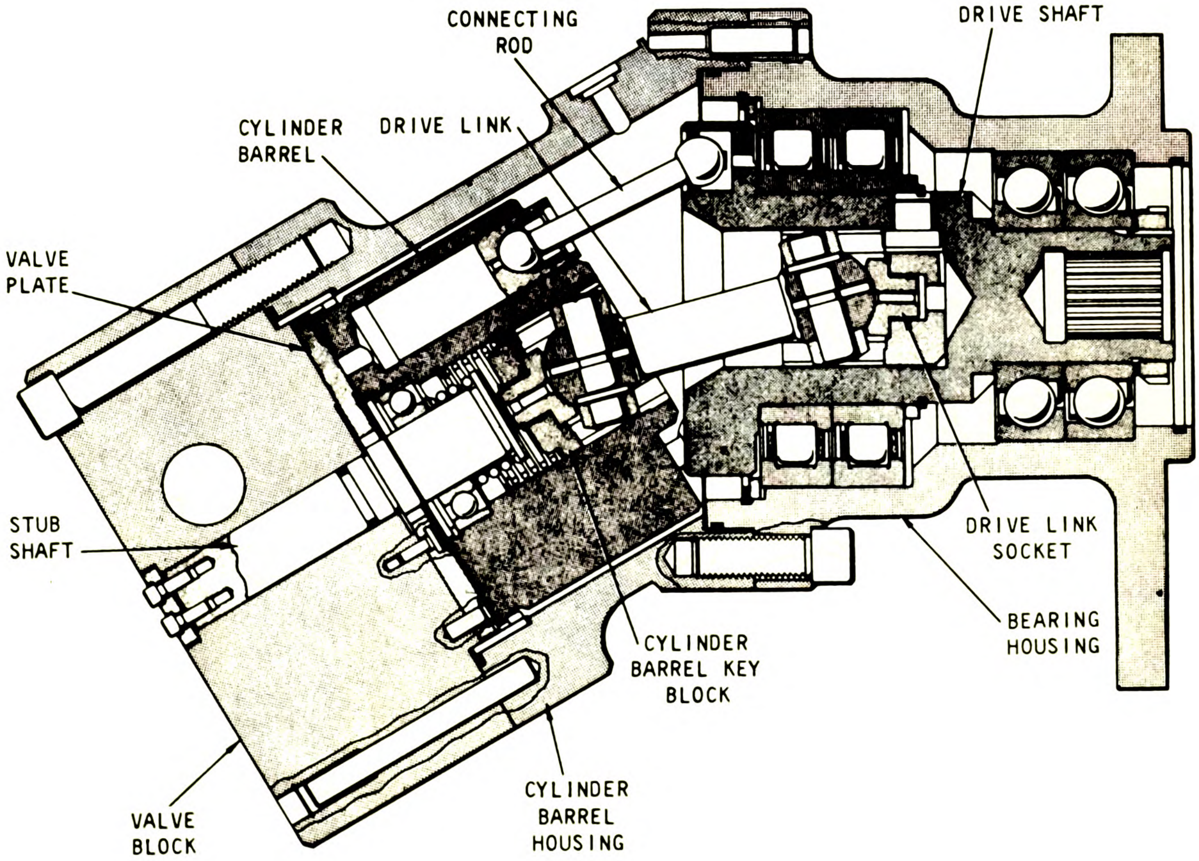
AIR BREATHER: Device which allows air to enter or leave a hydraulic tank as the oil level changes. An air filter is normally installed in the breather. (Refer to illustration #7-10.)

ANNEALING: Method of softening pipe and tubing so that it can be bent or formed more easily.

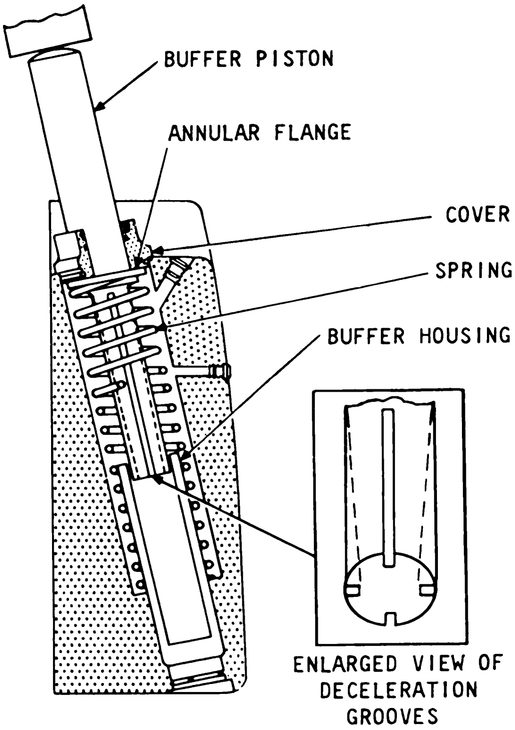
AXIAL PISTON PUMP: See PARALLEL PISTON PUMP.

BAFFLES: Plates or partial plates which extend into hydraulic tanks to reduce sloshing and foaming and to aid in cooling the fluid.

B-END: Hydraulic motor. (Refer to illustrations #7-2 and #7-4.)



7-2. B-END HYDRAULIC MOTOR

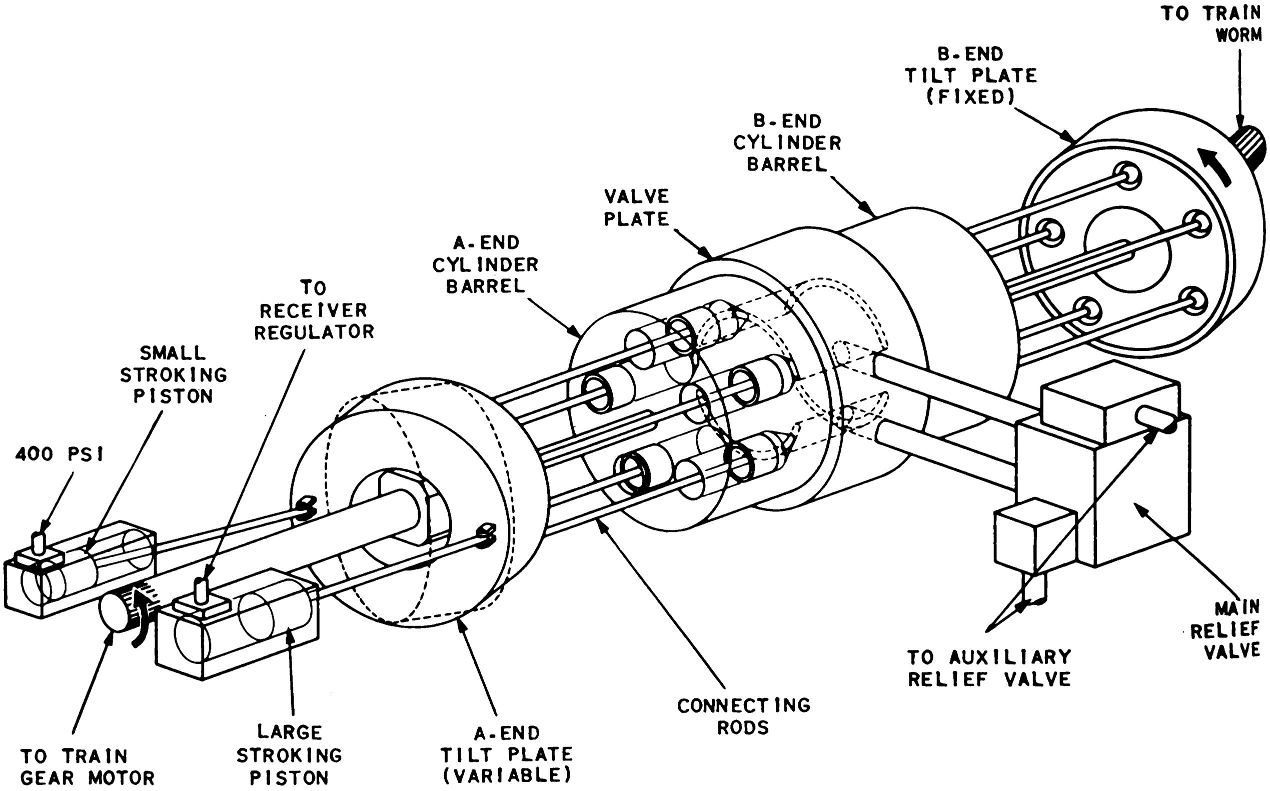


7-3. BUFFER

BUFFER: Mechanism used to retard or bring moving equipment to a smooth stop.

BYPASS VALVE: Valve used to let a volume of fluid bypass a hydraulic component. (Refer to illustration #7-11.)

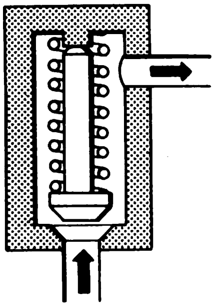
CAB UNIT (Combination A-end and B-end): A-end and B-end which are located in the same housing and are separated by a valve plate.



7-4. CAB UNIT

CAVITATION: Partial vacuum in hydraulic fluid caused by availability of less than a full volume of fluid at the pump intake.

CHECK VALVE: Device which permits hydraulic fluid flow in one direction only.

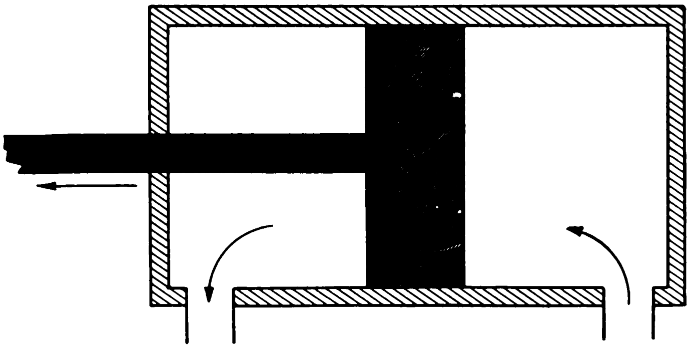


7-5. CHECK VALVE

CONSTANT DELIVERY PUMP: Pump that delivers a fixed volume of fluid.

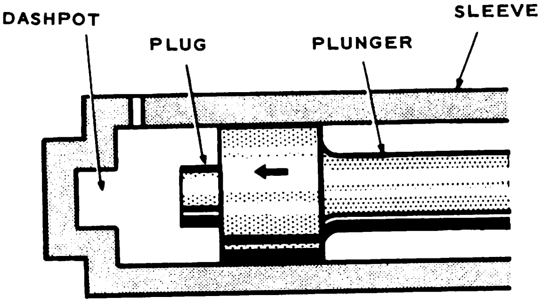
CONTROL FLUID (CONTROL PRESSURE): Hydraulic fluid (other than transmission fluid) under pressure used to control the operation of a hydraulic power unit.

CYLINDER AND PISTON: Linear motion device for converting fluid energy into mechanical energy.



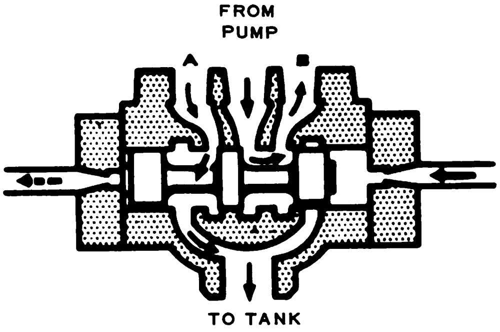
7-6. CYLINDER AND PISTON

DASHPOT: Device used to cushion the last portion of stroke and prevent metal-to-metal contact of pistons and plungers when they reach their ends of travel.



7-7. DASHPOT

DIRECTIONAL CONTROL VALVE: Valve which directs the flow or passage of fluid in a hydraulic system.



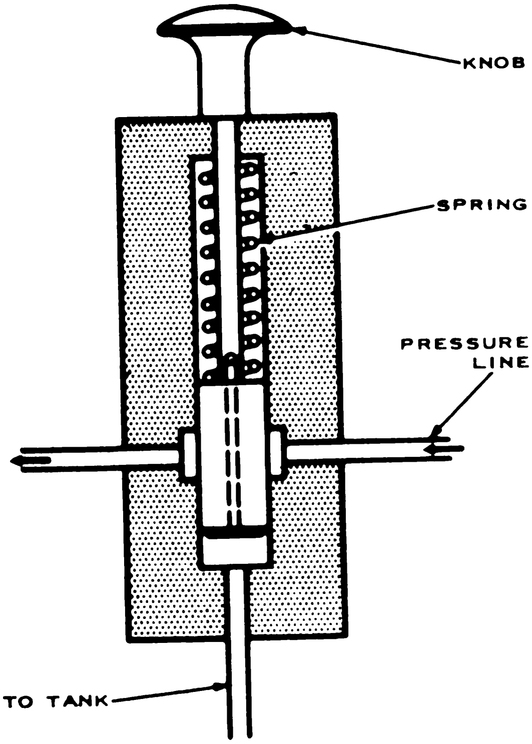
7-8. DIRECTIONAL CONTROL VALVE

DOWNSTREAM: Direction in which hydraulic fluid flows away from a hydraulic component, such as a valve, cylinder, etc.

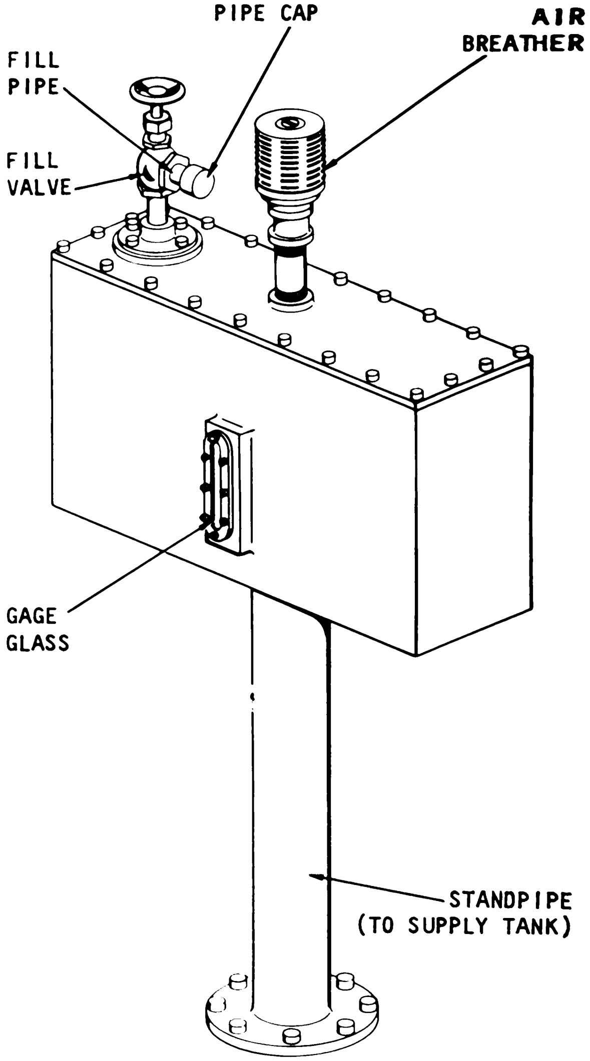
DRAIN LINES: Lines that return hydraulic fluid to the sump, supply, or header tanks.

DRAIN PLUG: Plug used to drain hydraulic fluid from a hydraulic system. (Refer to illustration #7-18.)

DUMP VALVE: Valve which, when actuated, dumps hydraulic fluid trapped in an accumulator system, normally manually operated.



7-9. DUMP VALVE

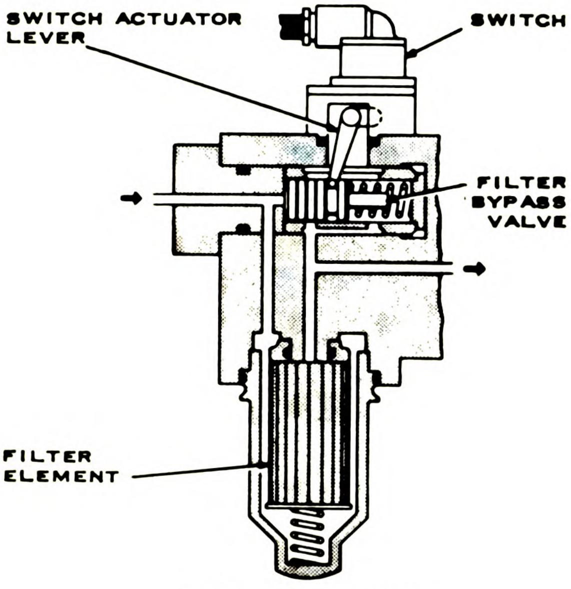


7-10. EXPANSION (HEADER) TANK

EXPANSION TANK (HEADER TANK): Tank, located above the hydraulic system, which provides space to allow for expansion and contraction of the fluid in a hydraulic system due to temperature changes. This tank also maintains a head of fluid in the system to prevent entry of air.

FILTER: Device for removal of dirt, sludge, and lint from a hydraulic fluid where the resistance to motion of such solids is in a tortuous path.

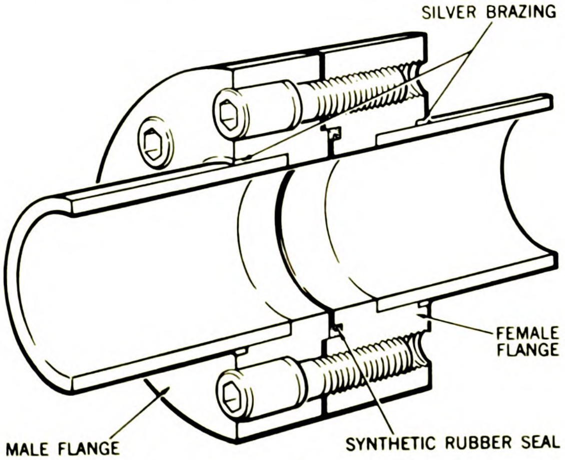
FITTINGS: Devices used to interconnect hydraulic pipes and tubing.



7-11. FILTER

FIRE POINT: Temperature at which a substance, if ignited, will burn for at least 5 seconds. The fire point is always higher than the flash point.

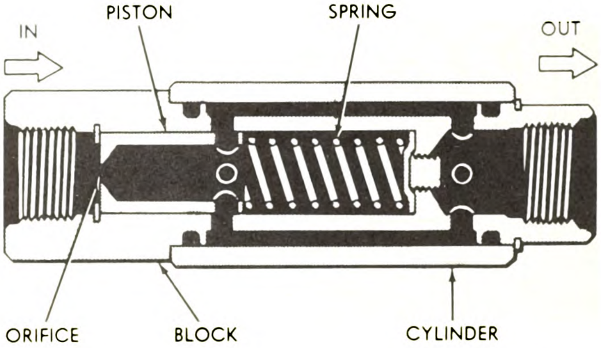
FLANGE FITTINGS: Block of metal in which tubing or pipeline is terminated. These fittings can be bolted to the equipment or to a companion flange to form a union connection.



7-12. FLANGE FITTING

FLASH POINT: Temperature at which a fluid gives off sufficient vapor to form a flammable mixture with air.

FLOW CONTROL VALVE: Valve which maintains a preset rate of flow regardless of pressure variations at its inlet or outlet.



7-13. FLOW CONTROL VALVE

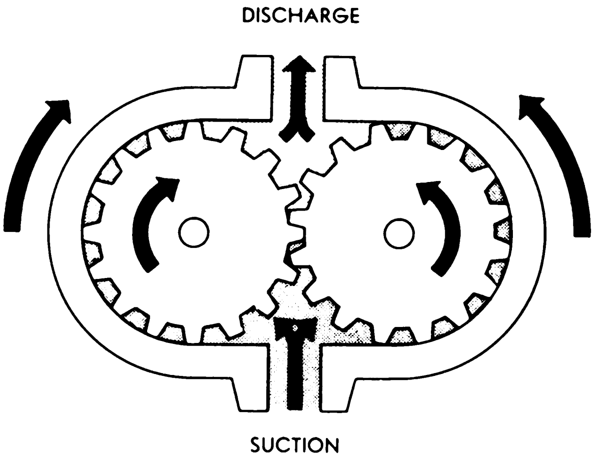
FLOW RATE: Number of units of volume of fluid passing through any channel in one unit of time. See VOLUME OF FLOW.

FLUID LEVEL GAUGE (GAGE) (sometimes called TANK WINDOW): Instrument which indicates the fluid level in a hydraulic system. (Refer to illustrations #7-10 and #7-18.)

GASKET: Material placed between mating surfaces of hydraulic fittings (flanges, etc.) to increase tightness of the seal.

GATE VALVE: Manually operated valve that controls the flow of fluid by means of a wedge (gate) which can be moved up and down across the line of flow.

GEAR PUMP: Constant delivery pump with two or more intermeshing gears acting as the pump rotor.



7-14. GEAR PUMP

GLOBE VALVE: Manually operated valve that controls the flow of fluid by means of a plug, ball, or disk which can be raised from or lowered into a valve seat.

GPM (GALLONS PER MINUTE): Normal way of measuring the volume of flow rate in a hydraulic system.

HEAD OF FLUID: Hydraulic fluid in a system that is maintained above the power drive level.

HEADER TANK: Tank which provides a static head of fluid for power drive operation. On some power drives, this tank may also be called expansion tank. (Refer to illustration #7-10.)

HOSE: Flexible hydraulic lines.

HYDRODYNAMICS: Study of liquids in motion.

HYDROSTATICS: Study of liquids at rest.

INHIBITORS (often called ADDITIVES): Chemicals added to hydraulic fluid to improve its ability to retard corrosion and foaming and to resist oxidation.

JIC SYMBOLS: Graphic symbols for fluid power (hydraulic schematic) diagrams. These symbols were originated by a Joint Industrical Conference of commercial hydraulic equipment manufacturers and are now included in MIL-STD-17B-1.

LINES: All external piping, tubing, and hose through which hydraulic fluid can flow.

LUBRICITY: Lubricating quality (oiliness) of hydraulic fluid.

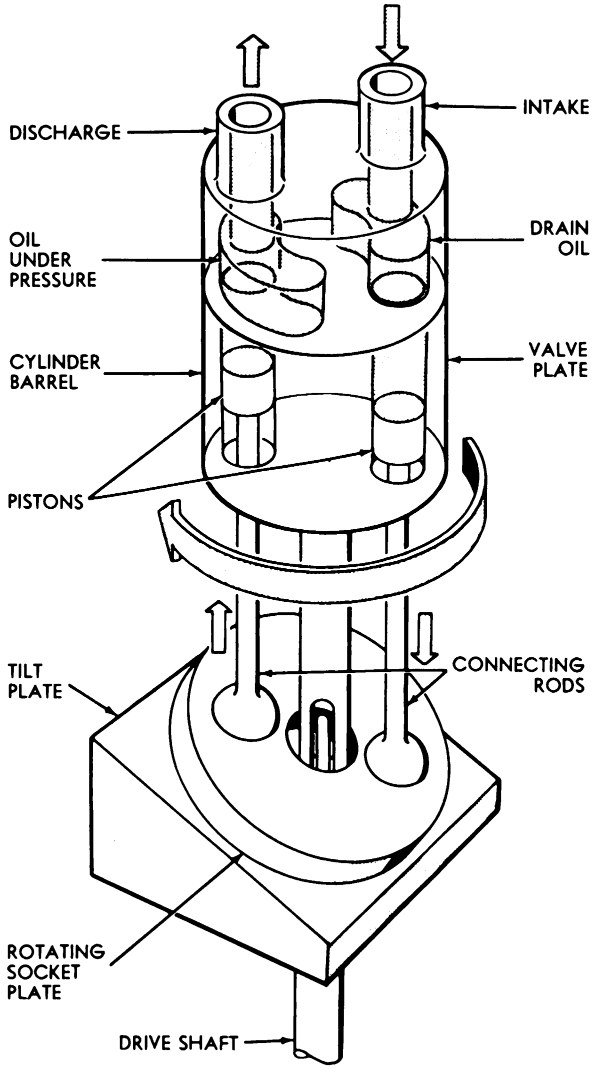
MOTOR (also called B-END): Device for converting fluid energy into mechanical energy.

ORIFICE: Restriction in a fluid passageway that controls or limits the rate of fluid flow. (Refer to illustration #7-13.)

OXIDATION: Chemical change in hydraulic fluid caused by oxygen which combines with the fluid during high temperature operation.

PACKING: Hydraulic seal to prevent leakage around a moving part, such as a piston rod.

PARALLEL PISTON PUMP (AXIAL PISTON PUMP): Pump in which pistons rotate on a shaft in such a way that the pistons are driven back and forth in their cylinders in a direction parallel to the shaft.



7-15. PARALLEL PISTON PUMP

PASCAL'S LAW: Law which states that pressure applied anywhere to a body of confined fluid is transmitted undiminished to every portion of the surface of the containing vessel.

PASSAGE: Machined hole or channel which lies in or passes through a hydraulic component and acts as a conductor of hydraulic fluid.

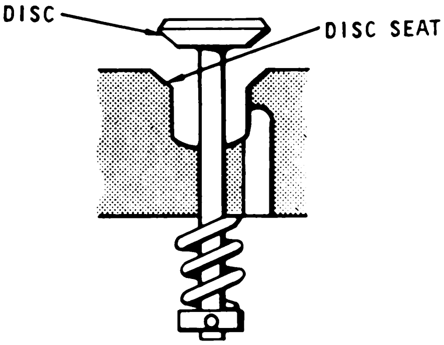
PICKLING: Method of removing scale from the inner surfaces of piping and tubing.

PILOT VALVE: Valve that controls the action of another valve.

PISTON, CYLINDER or BUFFER: Moving part of a hydraulic cylinder or buffer. (Refer to illustrations #7-3 and #7-6.)

PISTON, PUMP or MOTOR: Mechanical component of a pump or motor. The piston works in a cylinder and either moves the hydraulic fluid or is moved by the hydraulic fluid. (Refer to illustration #7-15.)

POPPET VALVE: Valve in the hydraulic end of a bag accumulator to prevent the synthetic bag from extending into the hydraulic manifold when there is no hydraulic fluid in the accumulator flask. (See poppet assembly in illustration #7-1.)



7-16. POPPET VALVE

PORT: Opening in a surface of a component, usually where hydraulic fluid enters or leaves a mechanism, such as a valve, piston, pump, etc.

POSITIVE DISPLACEMENT PUMP: Pump that dishcarges fluid in volumes separated by a period of no discharge. Pump types, such as axial piston, gear, and vane, may be considered to be several separate positive displacement pumps combined in one unit to smooth surges caused by the periods of no discharge.

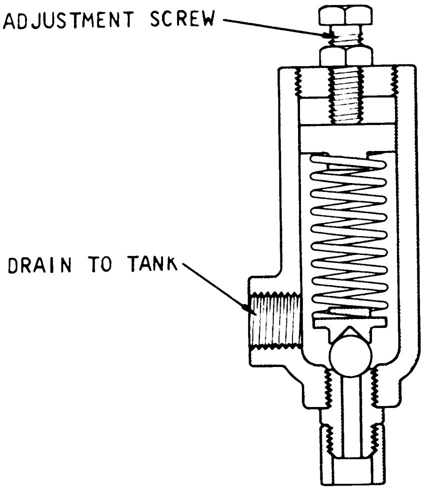
POUR POINT: Lowest temperature at which a fluid will pour or flow.

PRESSURE GAUGE (GAGE): Instrument that indicates the pressure in a hydraulic system.

PSI: Pounds per square inch.

PUMP: Device which converts meanical energy to hydraulic energy.

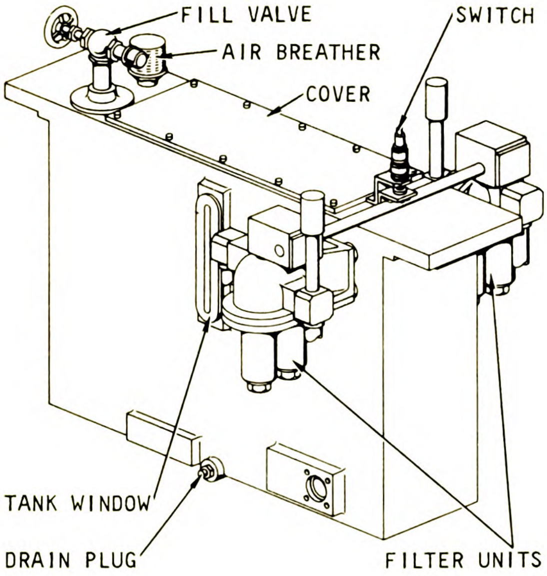
RELIEF VALVE: Valve which limits the maximum pressure applied to the portion of a hydraulic system to which it is connected.



7-17. SIMPLE RELIEF VALVE

REPLENISHING FLUID (also called SUPERCHARGE FLUID): Fluid used to replace any volume loss in power drive transmission lines (lines between the A-end and B-end).

RESERVOIR (also called SUPPLY TANK): Power drive tank used to maintain a supply of working fluid which may be drawn from as needed.



7-18. RESERVOIR (SUPPLY TANK)

RESTRICTION (also called CHOKE or ORIFICE): Device which produces a deliberate pressure drop in a line or passage by means of a reduced cross-sectional area. (Refer to illustration #7-13.)

ROTARY PUMP: Pump with rotor which carries fluid from intake to discharge on a curved path. Vane and gear pumps are classified as rotary pumps. (Refer to illustration #7-14.)

SEAL: Part or assembly of parts used to prevent hydraulic fluid leakage.

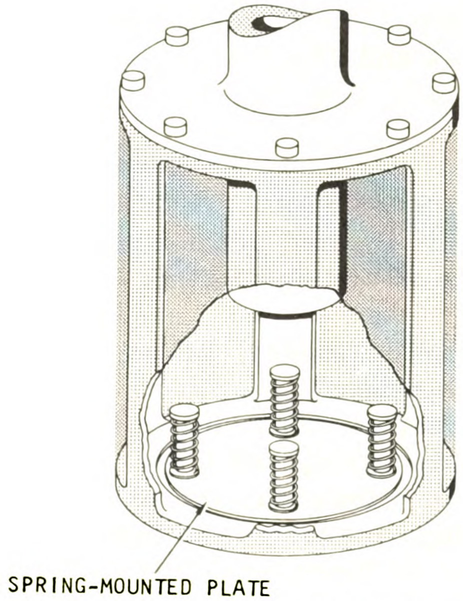
SERVO FLUID: Control pressure fluid in the hydraulic portion of a servo system.

SERVO SYSTEM: Closed loop control system which may or may not include a hydraulic power drive.

SERVO VALVE (also called PILOT VALVE or CONTROL VALVE): Valve in the hydraulic portion of a servo system that is normally controlled by an electrical error signal and that originates the hydraulic control signal.

SLUDGE: Gummy deposit caused by hydraulic fluid breakdown, mainly due to oxidation.

STRAINER: Device for removal of dirt, sludge, and lint from a fluid wherein the resistance to motion of such solids is in a straight line. A strainer is sometimes called a screen.



7-19. PUMP INTAKE STRAINER (SCREEN)

STROKE PISTON: Normally, a hydraulically controlled piston that controls the output of an axial piston variable delivery pump. (Refer to illustration #7-4.)

SUMP TANK: Tank usually enclosed within a power drive reservoir or supply tank to ensure available space for receiver regulator drainage.

SUPERCHARGE FLUID (sometimes called SUPERCHARGE PRESSURE): See REPLENISHING FLUID.

SURGE: Transient rise of hydraulic pressure in a hydraulic system.

TILT PLATE (or TILT BOX): Plate which is suspended by two trunnions and moved by the stroke piston(s) to control the output of a variable delivery radial piston pump. (Refer to illustrations #7-4 and #7-15.)

TRANSMISSION FLUID: Hydraulic fluid located in the lines between the A-end and B-end.

TUBING: Copper, brass, or steel hydraulic lines. It is common practice to call small hydraulic lines tubing and large lines piping. However, the Bureau of Ships makes no distinction between these terms; if the manufacturers call a product pipe, it is pipe; if they call it tubing, it is tubing.

UNLOADING VALVE: Valve used in accumulator power drives which directs pump output to the accumulator or to tank, in accordance with system demand.

UPSTREAM: Direction from which hydraulic fluid flows into a hydraulic component.

VALVE: Device for controlling flow rate, flow direction, or fluid pressure.

VARIABLE DELIVERY PUMP: Pump that delivers a variable volume of fluid.

VELOCITY: Rate or speed at which fluid is moving at a given point in a hydraulic system.

VENT (verb): To remove air from a hydraulic system.

VENT (noun): Threaded plug or needle valve used to remove air from a hydraulic system.

VISCOSITY: Measure of a hydraulic fluid's resistance to flow.

VISCOSITY INDEX (V.I.): Rate at which the viscosity of a fluid changes with temperature.

VOLUME: Quantity of hydraulic fluid.

VOLUME OF FLOW: Quantity of fluid (usually measured in GPM) that passes a given point in a hydraulic system in a given time.

TOPICS 2 THROUGH 20, 22, AND 23 OF SECTION 7

You Are Now Going To Learn:

1. Refer to appropriate topics in NavPers 92662, Vol. I, Section 1.

You Will Acquire Skill In:

1. Refer to appropriate topics in NavPers 92662, Vol. I, Section 1.

Discussion Points For These Topics Are:

1. Refer to appropriate topics in NavPers 92662, Vol. I, Section 1.

ASSIGNMENT:

A. Reference publication:

   1. Study NavPers 92662, Vol. I, Section 1, Topics 2 through 20, 22, and 23.

INFORMATION AND DISCUSSION:

The discussion points for Topics 2 through 20, 22, and 23 are thoroughly covered in the assignment. Study the text carefully and in proper sequence.

Sections 8 through 10

ELECTRICITY AND ELECTRONICS

ASSIGNMENTS

Section No.	Section Title	Page
8.	Weapon System Electricity	See page 186
9.	Weapon System Electronics	See page 186
10.	Special Circuit Applications	See page 186

ALL TOPICS OF SECTIONS 8 THROUGH 10

You Are Now Going To Learn:

Refer to appropriate section of NavPers 92662. (See ASSIGNMENTS.)

Discussion Points For These Sections Are:

1. Weapon system electricity.
2. Weapon system electronics.
3. Special circuit applications.

ASSIGNMENTS:

A. Reference publications:

   1. Study NavPers 92662, Vol. I, Section 2, Topics 1 through 9; Topics 12 through 22; and Topics 25 through 34.
   2. Study NavPers 92662, Vol. II, Section 4, Topics 1 through 9; Topics 12 through 18; and Topics 21 through 24.
   3. Study NavPers 92662, Vol. Vol. II, Section 5, Topics 1 through 8.

INFORMATION AND DISCUSSION:

The discussion points for Sections 8 through 10 are thoroughly covered in the assignments. Study the text carefully and in proper sequence.

Section 11

SYNCHRO-SERVO SYSTEM FUNDAMENTALS

ASSIGNMENT

Topic No.	Topic Title	Page
1. through 10.	Synchros	See page 188
11.	Synchro-Servo System	See page 188

TOPICS 1 THROUGH 11 OF SECTION 11

You Are Now Going To Learn:

Refer to appropriate section of NavPers 92662, Vol. I, Section 3, Topics 1 through 11.

Discussion Points For This Section Are:

1. Synchro-servo system fundamentals.

ASSIGNMENT:

A. Reference publication:

   1. Study NavPers 92662, Vol. I, Section 3, Topics 1 through 11.

INFORMATION AND DISCUSSION:

The discussion points for Section 11, Topics 1 through 11, are covered thoroughly in the assignment. Study the text carefully and in proper sequence.

Section 12

INTRODUCTION TO FIRE CONTROL

ASSIGNMENT-DISCUSSION-QUIZ SHEETS

Topic No.	Topic Title	Page
1.	Fire Control Fundamentals	190
2.	Fire Control System	200

TOPIC 1: FIRE CONTROL FUNDAMENTALS

You Are Now Going To Learn:

1. Importance of fire control.
2. Methods of firing.
3. Types of fire.
4. Factors to be considered in the fire control problem.

Discussion Points For This Topic Are:

1. Introduction to fire control.
2. Importance of fire control.
3. Fire-control terms.
4. Methods of firing.
5. Types of fire.
6. Factors to be considered in the fire control problem:
    a. Target motion.
    b. Own ship's motion.
    c. Force of gravity.
    d. Air resistance.
    e. Wind.
    f. Drift.
    g. Rotation and curvature of earth.
    h. Initial velocity of projectile.
    i. Parallax.
7. Review and summary.

ASSIGNMENT:

A. Reference publications:
    1. Optional reading list:
        a. NavPers 10173A, FT3.
        b. NavPers 10184, Volume 1, GM2.
        c. OP 1700, Standard Fire Control Symbols.

INFORMATION AND DISCUSSION:

In this topic guns, mounts, and projectiles will be discussed; the same information also applies to a certain extent to launchers and missiles.

Our Navy is only as strong as our ships are, and a ship is only as strong as its fire power. To be effective, fire power must be accurately controlled. To score a hit, the wild-game hunter has only to consider the lead for a moving target; fire control of modern weapons, however, is much more complicated. This control can be accomplished with the aid of precision instruments for sighting the target, for obtaining the proper range and bearing, and for laying the gun.

Modern guns can shoot with deadly accuracy at ranges of up to 20 miles. Some of our missile systems, however, have effective ranges in excess of 100 miles. Since these guns and missile systems are mounted onboard ship, the problem of fire control becomes more complicated due to the ship's movement, which sometimes resembles the motion of a cork being carried by a rough stream. Also, the target is usually maneuvering, that is, taking evasive action to escape a hit. With all these facts in mind, it can be understood why fire control is called the "science of laying the gun so that the projectile hits the target."

Considering the range at which targets are acquired and the speed at which they travel, one can readily see the need for highly accurate precision instruments. A gunner's mate must have his equipment in tip-top condition; however, if he has no means of accurately directing the gun so that the projectile contacts and destroys the target, the gun does not serve the purpose for which it is intended.

To better understand all the aspects of fire control, a person must become familiar with certain terms and their definitions. These terms will be helpful in understanding the language of fire controlmen and will also facilitate understanding of weapon system operations. Some of the most common terms used in fire control are listed below. (For other fire control terms, refer to GLOSSARY in Section 2, Topic 1, and to OP 1700.)

Laying the gun - Aiming the gun in such a way that the projectile hits the target.

Deck plane - Plane parallel to the ship's deck.

Horizontal plane - Plane tangent to the earth's surface or parallel to such a plane.

Vertical plane - Plane perpendicular (at right angle) to horizontal plane.

LOS (line of sight) - Line from director to target or from gunsight to target.

LOF (line of fire) or LOD (line of departure) - Line in which projectile is traveling at the instant it leaves the gun.

Range - Straight-line distance (in yards) from gun to target.

True target bearing - Angular value measured clockwise from north to line of sight.

Relative target bearing - Bearing of target measured clockwise from bow of own ship to line of sight.

Target elevation - Angle between horizontal plane and line of sight measured in vertical plane.

Trajectory - Curve of projectile from gun to first point of impact.

Roll - Angle between horizontal plane and deck plane measured in the vertical plane through a line perpendicular to own ship's centerline.

Pitch - Angle between horizontal plane and deck plane measured in vertical plane through own ship's centerline.

The method of sending a firing signal (impulse) to a gun is called the firing method. Two firing methods are used:

1. Pointer firing.

2. Master key firing.

The pointer at the gun can accomplish pointer firing in two ways, either by closing a key which sends an electrical current into the gun firing circuit (electrical firing) or by stepping on a pedal which operates a firing pin in the gun (percussion firing).

Master key firing is performed from a remote control station either by someone operating a key or automatically whenever the ship reaches a predetermined angle as it rolls or pitches with respect to the LOS.

Unlike guns, missiles must usually be fired by master key from a remote station (usually Weapons Control), except in emergency tactical situations. (More details about missile firing are provided in Section 19 of this Trainee's Guide.)

The ways in which firing of a gun or several guns is accomplished are defined as types of fire. Some of the common types of fire are defined as follows:

Salvo fire - Simultaneous firing of two or more guns at the same target. Salvos may be fired by entire batteries or by individual mounts.

Split salvo fire - Firing in which not all guns of a mount participate. Three 2-gun mounts may participate in a split salvo, provided that only one gun of each mount fires.

Partial salvo fire - Simultaneous firing of all guns in a mount, but not all mounts in the battery.

Continuous fire - Individual firing of each gun when ready.

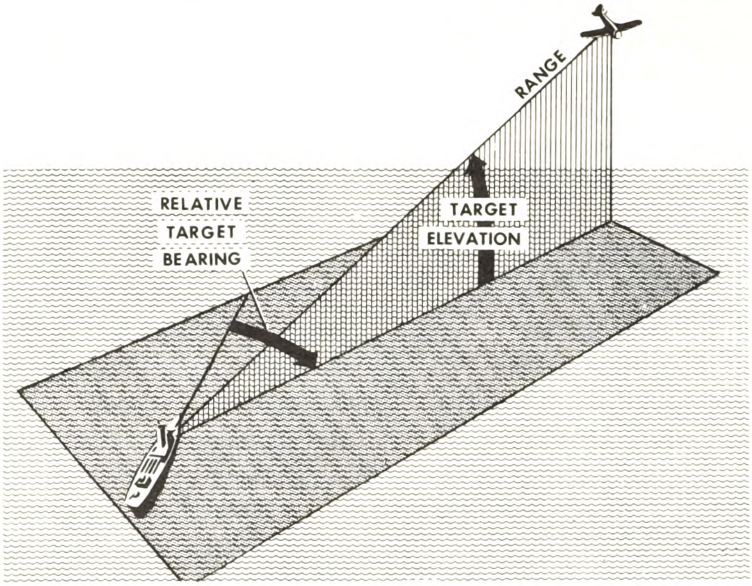
Slow fire - Delayed firing, to allow application of spots or corrections to conserve (save) ammunition.

Rapid fire - Firing that is not delayed for application of spots or corrections or to conserve ammunition.

If a moving surface-target is 15 miles away, a 16-inch projectile takes almost a minute from the time it leaves the muzzle of the gun until it gets to the target. If the target is making 40 knots an hour, it will have moved approximately 1,300 yards by the time the projectile has traveled 15 miles. The result would be a sure miss unless the gun is laid to lead the target by the correct angle.

If an air target is moving left or right, the gun train-angle will have to be corrected; if the target is moving away from or toward the ship, the gun elevation-angle will have to be corrected. (Relative target bearing, elevation angle, and range are shown on illustration #12-1 on the following page.)

The firing problem is still more complicated due to the fact that own



12-1. RELATIVE TARGET BEARING, ELEVATION ANGLE, AND RANGE FOR AIR TARGET

ship does not just swing around the hook, but also moves: It rolls and pitches because it is affected by ocean ground swells and waves. Therefore, the gun angles have to be automatically corrected to compensate for own ship's motion, roll, and pitch.

There are also other things to be considered. As the projectile speeds toward the target, the force of gravity pulls it down, the spin of the projectile pushes it sideways like a curving baseball, the wind shoves it one way or the other, and air resistance slows it down. Therefore, still more corrections to gun train and elevation are necessary.

Each type of gun is tested at the Naval Proving Grounds where a study of the effects of gravity, spin, wind, and air resistance is made for various gun elevation angles and ranges. The necessary corrections are then calculated and entered on range tables.

Modern computers are built to solve the problem of where to lay the gun, constantly allowing for instantaneous changes in motion of own ship and target.

When a target has been located, the following three values must be determined:

1. Range.
2. Relative target bearing.
3. Elevation angle.

Own ship's motion can easily be determined by means of the ship's gyro compass which shows own ship's course and by means of the pitometer log which indicates own ship's speed. When these values are known, the computer can determine the speed and course of the target relative to own ship and LOS.

Another important factor is roll and pitch of own ship. The ship rolls from side to side and pitches fore and aft. These movements tilt the trunnions (pivots on which the gun moves in elevation) out of level, thus causing an error in train and elevation. Since the gun is rarely trained to a 0 degree bearing, roll and pitch must be considered in relation to LOS. Roll and pitch are constantly being measured, and the results are supplied to the computer.

The fire control problem is not an easy one, for however fast the projectile moves, it still takes time to reach its destination. During that time, the projectile is affected by several disturbing factors; however, through the science of exterior ballistics (study of projectiles in flight) it has been determined what these disturbing influences are and how to compensate for them.

The four disturbing factors are:

1. Force of gravity.
2. Air resistance.
3. Wind
4. Drift.

Force of gravity is the first and most important factor affecting a projectile's course, since the force of gravity effects the trajectory curve. In interstellar space, there is little or no gravitational force; therefore, if a projectile would be fired in interstellar space, its trajectory would be a straight line. In the earth's atmosphere, however, the force of gravity is constantly pulling the projectile down, regardless of its velocity.

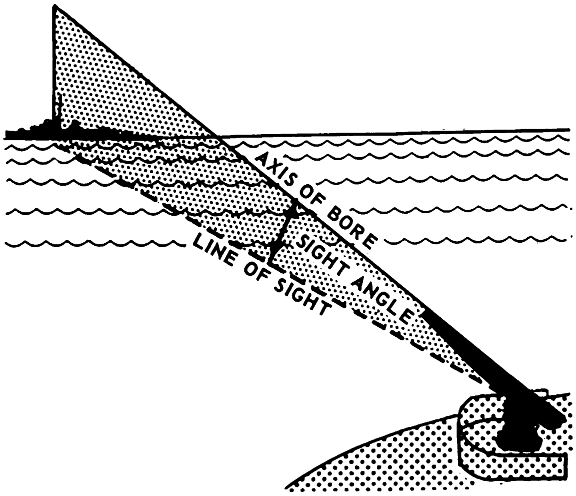
A projectile in flight is always falling; even firing from a gun cannot keep a projectile from falling. If a projectile were fired at 0 degrees elevation, that is, with the gun in perfect horizontal position, and at the same time another projectile of the same type were dropped over the side of the ship from exactly the same height as the gun, both projectiles would fall into the sea at the same instant. Of course, the projectile fired from the gun would be some distance away when it hits the water, but it would fall just as fast as the one which was dropped overboard.

To keep the projectile in flight until it reaches the target, the gun is elevated, that is, tilted at an angle so that it is directed toward a point above the target. If the tilt angle is correct, the trajectory will pass through the target. However, the distance a projectile can travel in this way is limited.

If the effects of air resistance

would not exist, the range of the projectile would increase with the angle of elevation up to 45 degrees. If the elevation angle would be increased to exceed 45 degrees, the height reached by the projectile would be increased, but its range would be decreased.

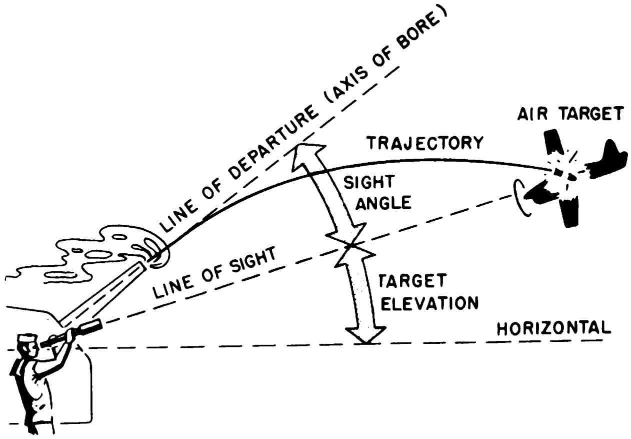
The angle by which the gun is elevated to attain the desired range is called the sight angle. The sight angle is defined as a vertical angle and is measured in degrees and minutes between LOS and LOD. (Refer to illustration #12-2.)



12-2. SIGHT ANGLE

The sight angle is not the same as the target elevation angle. While the sight angle is measured between LOS and LOD, the target elevation angle is measured between LOS and the horizontal plane. (Refer to illustration #12-3.)

Since the pull of gravity within the heights reached by projectiles may be considered to be everywhere the same, the behavior of projectiles is fundamentally uniform, and the gun therefore may be elevated accordingly to acquire the desired range.

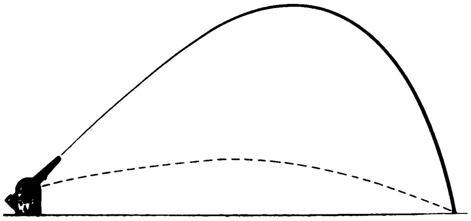


12-3. SIGHT ANGLE AND TARGET ELEVATION ANGLE

Air resistance is the second disturbing force which affects the flight path of a projectile. A projectile speeding along at nearly half a mile per second does not fly through the air -- it seems to "plow" through it.

The air disturbance created by the projectile shows up its flight, thus keeping the projectile from going as far and as high as it would in a vacuum and also causing it to fall at a steeper angle.

Air resistance can be compensated for by increasing the range through additional gun elevation (increase of sight angle). (Refer to illustration #12-4 on the following page. The dotted line shows the trajectory of a projectile in a vacuum; the solid line shows the trajectory of a projectile in the air. The gun is elevated to increase range of projectile.) Air density varies with altitude and barometric pressure. The amount of necessary compensation depends not only on range, but also on altitude of the projectile and weather conditions at time of firing.



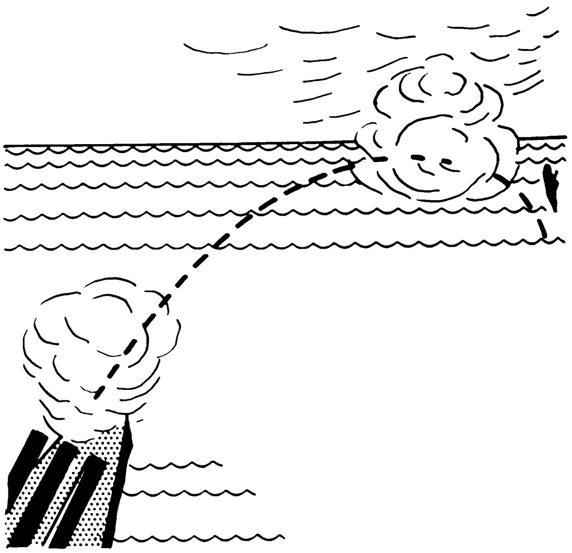
12-4. COMPENSATION FOR AIR RESISTANCE

Wind is the third disturbing force. Air density affects the flight of a projectile whether the air is moving or not. For the sake of simplicity, in this discussion it was assumed that the air does not move. However, it does move, and this movement is called wind.

Wind is not only air movement, but also movement with respect to something else. If this air movement is in respect to something stationary (the earth, for example), it is called true wind.

On a moving ship, even if a dead calm exists, there is air movement. In terms of gunnery, that movement is considered wind. If the ship is moving north and if the true wind is coming from the west, a northwest wind is felt. This wind, caused by air movement and ship movement, is called apparent wind.

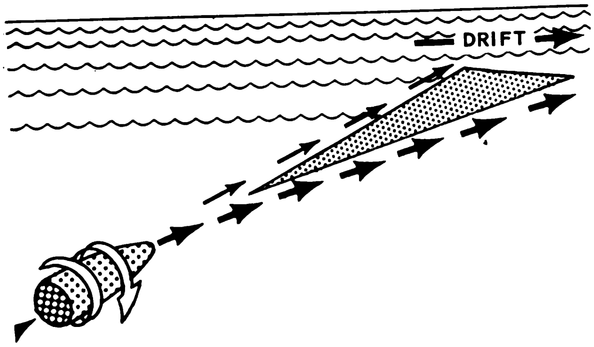
The effect of wind on the flight of a projectile depends on the strength of wind that blows across the line of fire (crosswind) and on the strength of wind that blows along the line of fire (range wind). The range wind tends either to push the projectile forward or to blow against it and retard its flight. In a similar way, the crosswind pushes the projectile either to the right or to the left, thereby deflecting its path.



12-5. EFFECT OF WIND ON PROJECTILE FLIGHT

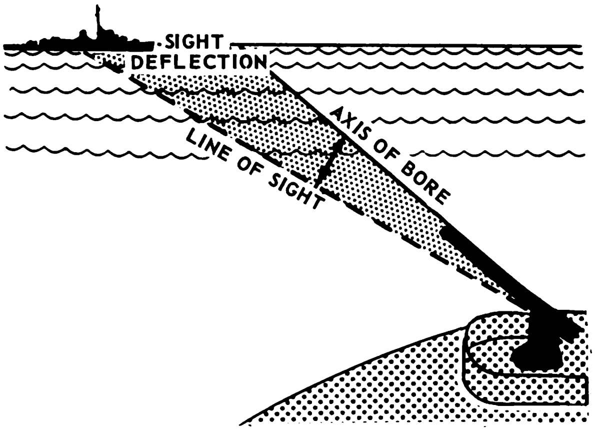
When absolute accuracy is desired, balloons are sent aloft and are observed, to measure the wind at various altitudes. When all measurements have been taken into account, they are averaged and the result is called ballistic wind. Compensation for the effect of ballistic wind is made in fire-control calculations.

Drift, the fourth disturbing factor, is caused by the interaction of the clockwise spin of the projectile combined with the force of gravity and air resistance. The effect of drift is a deflection of the projectile's course to the right. (Except for .45-caliber pistols, all guns in the U.S. Navy fire projectiles that drift to the right.) Drift increases with range and is independent of wind. Drift should not be confused with wind effects.



12-6. EFFECT OF DRIFT ON PROJECTILE

Because of drift, wind, own ship's movement, target movement, and other disturbing factors, it is seldom possible to train a gun directly on a target, except at pointblank range; almost always the gun has to be trained or deflected somewhat from the line of sight, deliberately starting the projectile on an apparently wrong course in order to hit the target. The amount of deflection (horizontal angle between LOS and LOD) is called sight deflection.



12-7. SIGHT DEFLECTION

Rotation and curvature of the earth may also affect the fire control problem. So far in this discussion, it has been assumed that the earth stands still and is flat. Actually, however, its movement has an effect on projectile trajectories, and its curvature has an effect on the range, but these two effects begin to be important only at extreme ranges - 30,000 yards or more.

As already mentioned, if the location and motion of a target are known, it can be determined where the target will be when the projectile hits it. After the factors which may cause a projectile to go off its course and the conditions under which a projectile has to travel have been considered, the behavior of a projectile can be predicted.

The following discussion will concern the influences of the gun itself on the flight of a projectile.

The start of a projectile determines

its course. The important factors in the start of a projectile are its initial speed, also called initial velocity or I.V., and its direction. A reduced I. V. reduces range; the effect of a projectile's start in the wrong direction is obvious.

The main influences affecting a projectile's initial velocity are:

1. Wear of gun bore (erosion).
2. Variations in temperature of the propelling charge of the ammunition.
3. Variations in actual weight of the projectile.

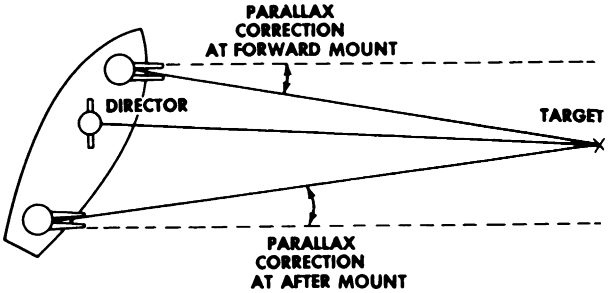
Erosion causes enlargement of the gun bore which, in turn, cuts down the initial velocity and range of the projectile and also the accuracy of fire.

By lowering the temperature of the propelling charge, the initial velocity and range of the projectile are reduced. The standard initial velocity, which is determined at the Naval Proving Grounds, is based on powder (propelling charge) temperature of 90°F. (Higher temperature increases initial velocity and range.)

Variations in projectile weights are not as important in determining I. V. as the other two factors mentioned. The values of these two factors are either built into the computer or are inputs to the computer during its operation. When all the information is supplied to the computer, it solves the gun elevation and train orders so that the gun can be laid to assure a hit.

In order for the lines of sight from two remotely located stations to converge on the same target an angular correction is necessary. This correction is called parallax. For example, illustration #12-8 shows a typical ship with guns fore and aft and a midship director. If the gun train orders are based on the director's line of sight, a correction of each gun is necessary to permit all three lines of sight to converge on the target.

Parallax may be either vertical or horizontal. Horizontal parallax is more important than vertical par-


PARALLAX CORRECTION AT FORWARD MOUNT
DIRECTOR
TARGET
PARALLAX CORRECTION AT AFTER MOUNT

12-8. HORIZONTAL PARALLAX

allax, because greater distances are involved.

The horizontal angle between the bore axis of the gun and the director's line of sight is the horizontal (train) parallax. The further the gun is from the director, the greater the parallax angle for any given range. However, as range increases, parallax decreases.

Horizontal parallax correction varies with each mount, depending on the distance from mount to director. The parallax correction computed in the fire-control system and transmitted to all gun mounts is the same for any given range. This correction (unit parallax) is based on the assumption that all gun mounts are one hundred yards from the director. Based on the actual horizontal distance of the director from the mount, the unit correction is converted to the proper correction by a set of change gears in each mount.

The fire-control system may also compute parallax corrections for the vertical distance between guns and director. Because all guns are approximately the same vertical distance from the director, no change gears are used, and the correction is transmitted as part of the order signal(s).

Equipment used to determine various factors to be considered before firing a projectile will be discussed in Topic 2 of this section.

TOPIC 2: FIRE CONTROL SYSTEM

You Are Now Going To Learn:

1. Functions of a fire control system.
2. Location and purpose of fire control system components.
3. Flow of information in a fire control system.

Discussion Points For This Topic Are:

1. Requirements of a fire control system.
2. Location and functions of the following units:
    a. Director.
    b. Radar.
    c. Rangefinders.
    d. Stable element.
    e. Computer.
3. Functions of missile fire-control computers.
4. Flow of fire-control information.
5. Review and summary.
6. Section review.
7. Written test.

ASSIGNMENT:

A. Reference publications:
    1. Optional reading list:
        a. NavPers 10173A, FT3.
        b. NavPers 10174, FT2.
        c. NavPers 10184, GM2.

INFORMATION AND DISCUSSION:

In Topic 1 of this section the factors to be considered in gunlaying have been discussed. In Topic 2, the major fire-control units which constitute a fire-control system will be explained.

Fire-control systems (FCS) vary on different ships and for different gun and weapon systems. It would be impossible, in the time allotted, to describe all fire-control systems; therefore, unless otherwise noted, in this topic primarily the FCS Mk 37 will be discussed. (The FCS Mk 37, which was designed to control the 5"/38-cal. gun mount, is widely used in main batteries of destroyers and in secondary batteries of many cruisers.)

A fire-control system must be capable of performing the following tasks:

1. Locating the target.
2. Establishing target present position.
3. Predicting target future position.
4. Compensating for roll and pitch of the ship.
5. Correcting external ballistics.
6. Computing the gun or launcher elevation and train orders.
7. Computing the sight angle and sight deflection (only for some guns, not for missiles).

The four major units required to perform these tasks are listed below:

1. Director.
2. Radar and/or rangefinder.
3. Stable element or stable vertical.
4. Computer or rangekeeper.

Directors are mounted on high points of the ship (refer to illustration #12-9) and usually support the radar antenna and/or rangefinder. To supply the necessary energy for training the director and for controlling the optics of the director in elevation, power drives are used. The elevation power drives position the radar antennas and rangefinder prisms in step with the director optics.

Gun system directors are usually manned and can be locally controlled either by handwheels or by slew sights (one-man control stations). Missile system directors are remotely controlled from control (plotting) rooms which are located below the directors. When tracking a target, the director transmits present target train and elevation bearings to the computer in the plotting room.

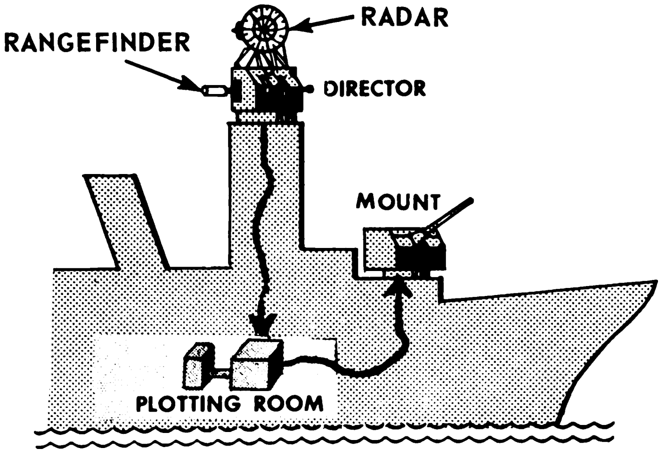
By means of radio echoes, radar determines the presence of objects, their ranges, bearings, and elevations. Radars aboard ship can be broadly classified either as search or as fire-control radars.

Most of the search radars are capable of target detection at long ranges with fair precision. Search radars are used to provide approximate data on distant targets, to control friendly aircraft, and to serve as navigation aids.

Fire control radars are capable of determining rather precisely the range, bearing, and elevation of a target; however, fire control radars are more limited in range than search radars.

Usually, fire-control radars are mounted on the director (refer to illustration #12-9), but on at least two presently used antiaircraft (AA) fire-control systems the radar antennas are mounted on the gun mounts.

Fire-control radars are classified either as surface or as antiaircraft radars. Surface radars



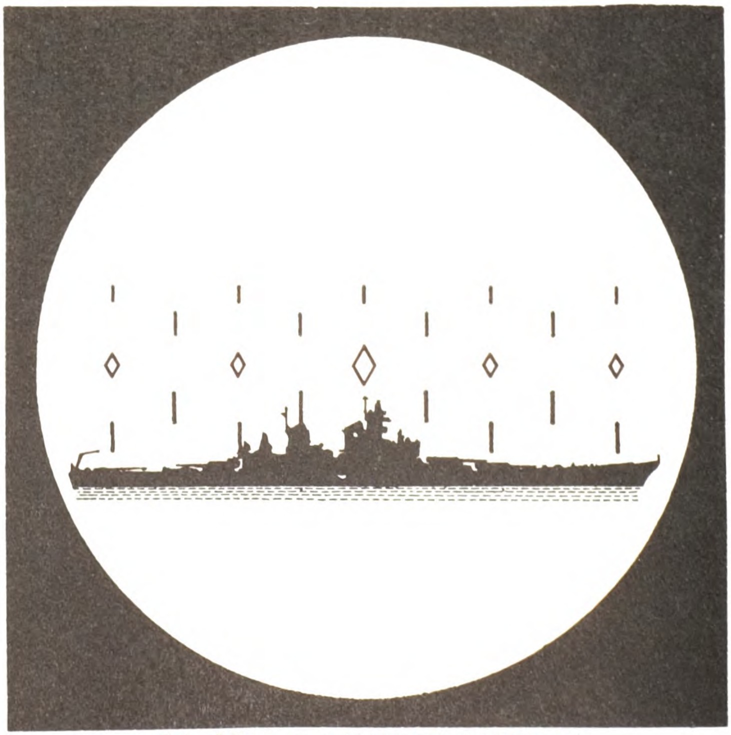
12-9. FIRE CONTROL SYSTEM, GENERAL ARRANGEMENT are used primarily with main batteries of large ships, to obtain the bearing and range of surface targets (enemy ships) and for shore bombardment.

Antiaircraft radars, in addition to supplying target range and bearing data, also determine target elevation. Antiaircraft radars, except for certain types used with machinegun batteries, are capable of automatically tracking a target. During tracking of a target in automatic control, the director "locks on" and follows the radar signal.

Antiaircraft radars used with the fire-control systems Mk 37, Mk 56, and Mk 68 (which primarily control dual-purpose guns) may also be operated in a surface-mode of control.

To determine target range, optical rangefinders were used long before radar was invented. Optical rangefinders consist of a system of optical units assembled in a long tube. The rangefinder tubes are still mounted in the directors of all surface fire-control systems and in the AA fire-control systems Mk 37 and Mk 68. Optical rangefinders all receive crosslevel signals from the stable element to keep the rangefinder tube in the horizontal plane when the ship is rolling.

Rangefinders are classified either as stereoscopic or as coincidence rangefinders. (Almost all fire-control system rangefinders are stereoscopic.) In a stereoscopic rangefinder, the reticle pattern is composed of ranging marks. (Refer to illustration #12-10.)



12-10. RANGING MARKS

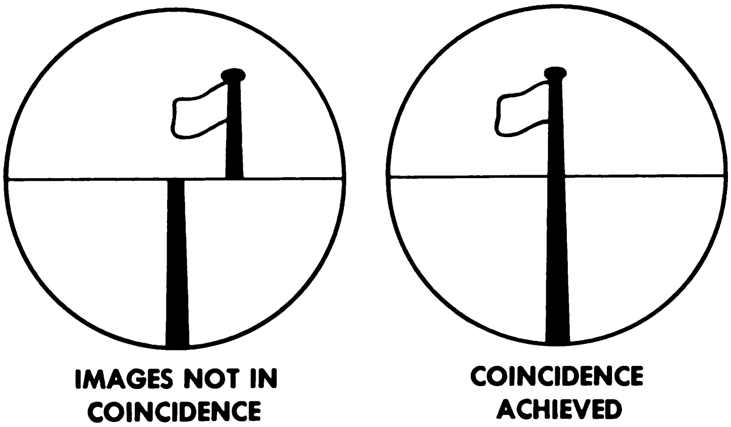
To operate a stereoscopic rangefinder, the operator must position the large center diamond, by means of a control knob, directly over the target. Then he reads the range from a dial on the rangefinder. The small diamonds are used in target spotting.

Not everyone is capable of accurately operating stereoscopic rangefinders; therefore, in the past, qualified rangefinder-operators in the Navy were so important for good gunnery that they were paid extra money.

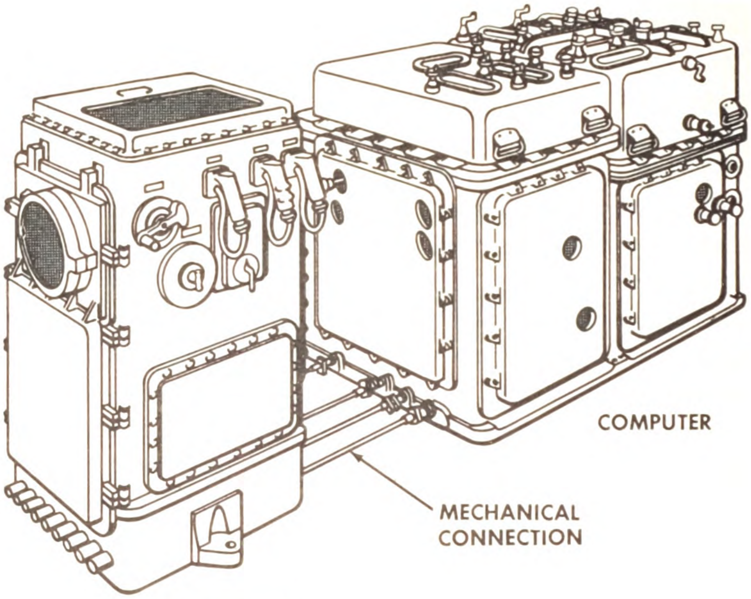
Externally, the coincidence rangefinder is similar to the stereoscopic rangefinder. The image on a coincidence rangefinder is split. (Refer to illustration #12-11.) When the two halves of the image are properly matched, a correct range reading can be taken. Coincidence rangefinders are easier to operate than the stereoscopic type, but they are neither as accurate nor as well adapted for tracking aircraft targets as are the stereoscopic ones. Besides, coincidence rangefinders are almost useless for spotting.

The stable element is located in the plotting room (refer to illustration #12-9 on page 201) and, by means of a gyro, measures the roll and pitch of the ship. The resultant signals, level (in the line of sight) and crosslevel (across the line of sight), are then transmitted to the computer where these signals are used to compensate for roll and pitch so that the guns and optics in the director are not affected by the ship's movements.

Surface (main battery) fire-control systems use an instrument called a stable vertical which is similar to the stable element, except for certain details. (Illustration #12-12 on the following page shows the general configuration of the stable element used in fire-



12-11. COINCIDENCE RANGEFINDER IMAGE



12-12. FIRE CONTROL SYSTEM MK 37, STABLE ELEMENT AND COMPUTER

control system Mk 37.)

The computer, which is the heart of the fire-control system, is located in the plotting room. Computers can be either of mechanical or of electronic type, or a combination of both types. The computer solves from input information the fire-control problems. The solutions appear in the form of electrical output signals which control gun-laying, director operation, and sighting (in gun and director).

In fire-control systems that control guns which fire projectiles fitted with time fuzes, the computer must also generate fuze-setting time which is determined by the future range of the target. Computers used in surface fire-control systems perform the same basic operations as antiaircraft fire-control computers, only the surface computers are called rangekeepers.

Missile fire-control system computers are more complicated and compute more data than gun fire-control system computers. Certain types of computers are capable of solving gun and missile control problems simultaneously.

The following is a list of typical functions of a missile fire-control system computer:

1. Control of director during target acquisition.
2. Control of launcher in train and elevation during target tracking.

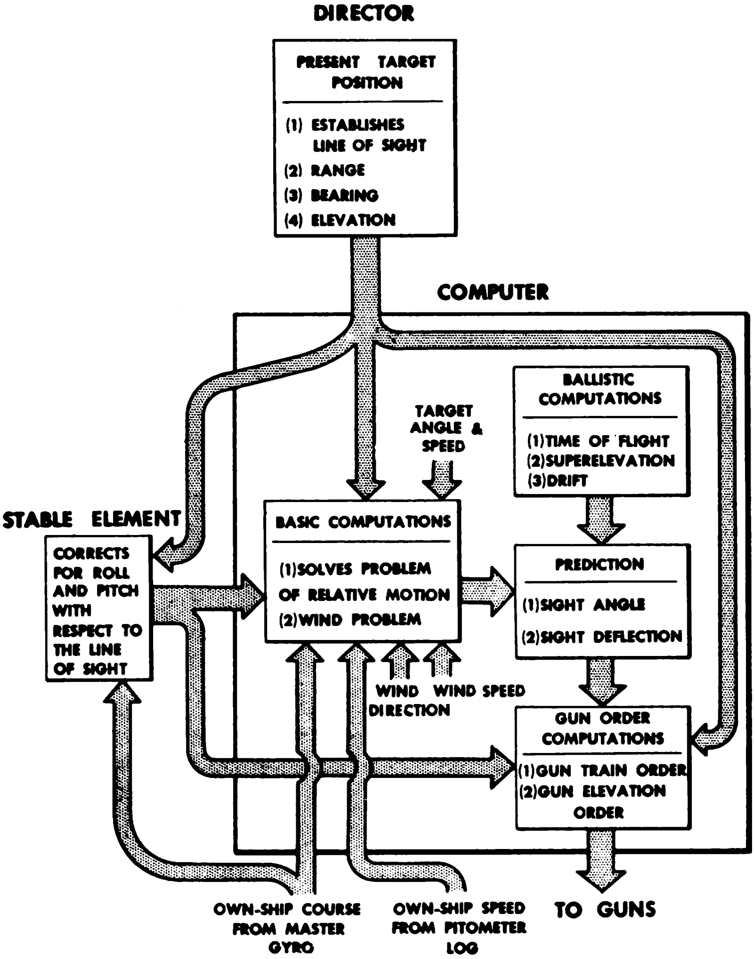
3. Generation of roll-gyro correction-signals for the missile while the missile is on the launcher.

4. Generation of roll correction signals for orientation of the capture and guidance beams.

5. Computation of present and future target positions and effective missile range for prefiring evaluation.

6. Computation of director "busy-time" (estimated and computed time from the instant the target is assigned until a "kill" is made).

Illustration #12-13 shows a simplified flow of information in a typical gun fire-control system. The director locates the target and transmits the present target position to the computer. Present target position includes present range,

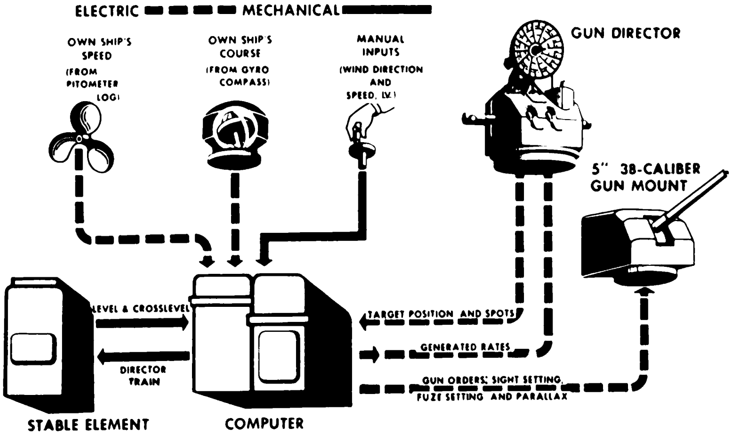


12-13. FIRE CONTROL SYSTEM SOLVING THE PROBLEM bearing, and elevation of target. Range is actually determined by either a radar or a rangefinder located in the director.

After the director has tracked the target for a very short time (usually a few seconds) the computer automatically computes the target angle and target speed. The computer then uses the present target position, target angle, and target speed plus roll and pitch, own-ship's speed, and own-ship's course, to solve the problem of relative motion between own ship and target. The relative motion problem is solved by using the vector process. This solution determines the rates of movement (changes per second) between own ship and target. The rates of movement, bearing rate, elevation rate, and range rate are transmitted to the director (refer to illustration #12-14) where, if necessary, they are corrected by the director operators.

These rate quantities are also transmitted to the prediction section of the computer where the relative motion corrections are combined with wind, drift, time-in-flight, and superelevation data, to determine the sight angle and sight deflection.

Sight angle, sight deflection, and the corrected target bearing and elevation angles are integrated with the roll and pitch (level and cross-level) signals and are transmitted to the guns as sight angle, sight deflection, train order, and elevation order.


ELECTRIC
MECHANICAL
OWN SHIP'S SPEED (FROM PITOMETER LOG)
OWN SHIP'S COURSE (FROM GYRO COMPASS)
MANUAL INPUTS (WIND DIRECTION AND SPEED, IV.)
GUN DIRECTOR
5" 38-CALIBER GUN MOUNT
LEVEL & CROSSLEVEL
DIRECTOR TRAIN
TARGET POSITION AND SPOTS
GENERATED RATES
GUN ORDERS: SIGHT SETTING, FUZE SETTING AND PARALLAX
STABLE ELEMENT
COMPUTER

12-14. FLOW OF INFORMATION IN FIRE CONTROL SYSTEM MK 37

QUIZ SHEET:

1. Standard initial velocity, determined at the Naval Proving Grounds, is based on a powder (propelling charge) temperature of

   a. 72 degrees.
   b. 65 degrees.
   c. 90 degrees.
   d. 87 degrees.

2. Wind caused by movement of both air and ship is called

   a. True wind.
   b. Relative wind.
   c. Range wind.
   d. Apparent wind.

3. Counterclockwise spin of a projectile causes the projectile to drift to the right.

   True ______ or False ______.

4. Fire which is controlled from a remote control station is called

   a. Trainer fire.
   b. Master key fire.
   c. Pointer fire.
   d. Direct fire.

5. The angle between the line of sight and the line of departure is called

   a. Train angle.
   b. Target elevation.
   c. Elevation angle.
   d. Sight angle.

6. The further the gun is from the director, the greater the parallax angle.

   True ______ or False ______.

7. The directors of missile fire-control systems are usually manned.

   True ______ or False ______.

8. Antiaircraft fire-control radars differ from surface fire-control radars by the feature that the antiaircraft fire-control radars also transmit target elevation information.

   True ______ or False ______.

9. The small diamonds (rangemarks) in stereoscopic reticles are used for

   a. Aligning.
   b. Spotting.
   c. Centering.
   d. Focusing.

10. The coincidence rangefinder is easier to use, but is less accurate than the stereoscopic rangefinder.

    True ______ or False ______.

11. The stable element measures roll and pitch of a ship by means of a/an

    a. Level.
    b. Gunner's quadrant.
    c. Error recorder.
    d. Gyro.

12. From input information, a fire-control system computer provides a continuous solution to the fire-control problem.

True ______ or False ______.

13. The four major units necessary for performing the tasks of a fire-control system are

a. ______________________________.
b. ______________________________.
c. ______________________________.
d. ______________________________.

14. Surface fire-control systems are used to obtain the bearing, range, and elevation of a target.

True ______ or False ______.

15. The stable element transmits own ship's course to the fire-control computer.

True ______ or False ______.

Accuracy of notes checked by instructor:

Date ______________________________

Trainee's initials ______________________________

Section 13

AUTOMATIC WEAPON CONTROL EQUIPMENT

ASSIGNMENT-DISCUSSION-QUIZ SHEETS

Topic No.	Topic Title	Page
1.	Introduction to Control Equipment	210
2.	Electric-Hydraulic Power Drives and Their Operation	214
3.	Amplidyne Follow-Up System Components and Operation	218
4.	Shipboard Tests and Test Equipment	224

TOPIC 1: INTRODUCTION TO CONTROL EQUIPMENT

You Are Now Going To Learn:

1. The purpose and application of automatic control equipment.
2. The functions of power drives used in automatic control equipment.
3. Operational sequence of signal flow.

You Will Acquire Skill In:

1. Tracing the signal flow through the components of the automatic control equipment.

Discussion Points For This Topic Are:

1. General information about automatic control equipment.
2. Purpose and functions of automatic control equipment.
3. Power drives used in automatic control equipment.
4. Sequence of signal flow.
5. Review and summary.

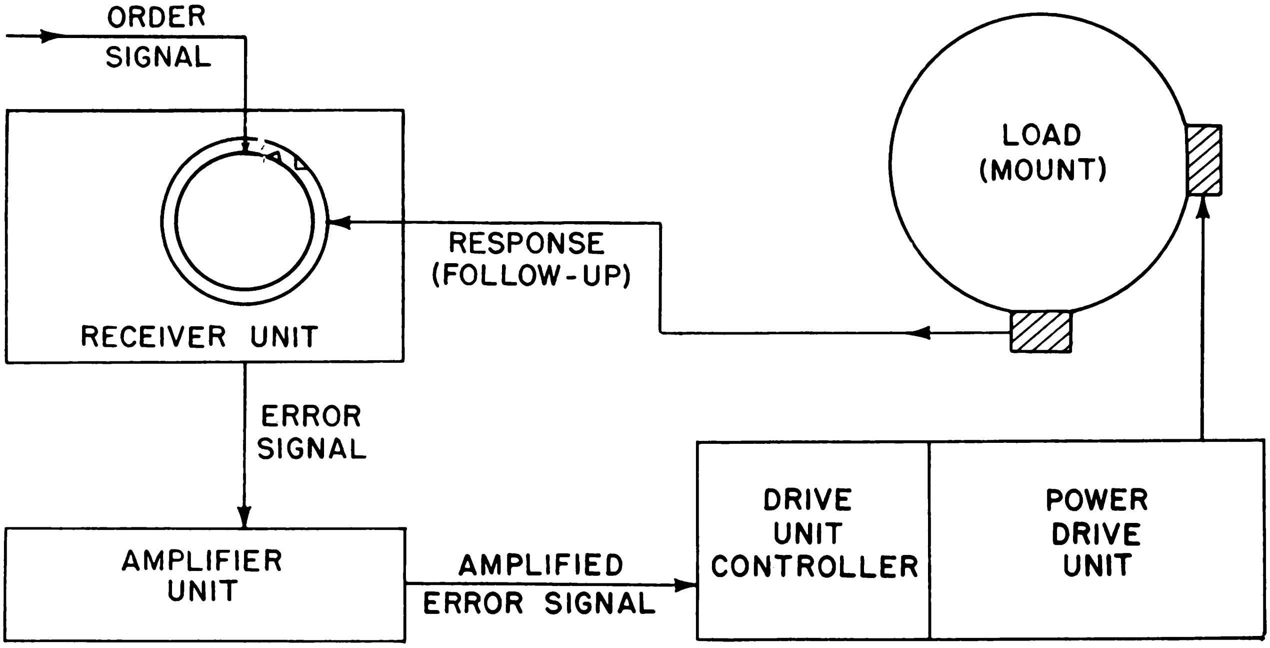
INFORMATION AND DISCUSSION:

The automatic control equipment to be discussed in this section comprises the train and elevation power drives for mounts, turrets, and launchers.

A power drive is a part of the basic automatic servo system. (Refer to diagram #13-1 on following page and to the reference publications listed in assignment of Section 11.) Power drives can be automatically controlled from a remote station which consists of a director or computer.

The automatic control equipment is designed to comply with the nature and source of the signal, the weight of the load to be moved, and the type of damping required to eliminate random movements, to ensure accuracy and rapidity of response.

The training and elevating of guns by means of manually controlled power equipment (either by matching indicating dials or by using telescopes) is relatively difficult and inaccurate. Some of the disadvantages of manual control are: Fluctuations in the incoming gun orders, inertia of heavy turrets or mounts, rolling and pitching of the gun platform, and the reaction time of the individual pointers and trainers observing and responding to order variations. These factors cause inaccuracy in gun-laying which re-



13-1. OPERATIONAL SEQUENCE OF SIGNAL FLOW OF A BASIC AUTOMATIC SERVO SYSTEM

sults in large dispersion in the fall of shot.

The advantages of automatic control equipment are the speed and accuracy with which guns and launchers may be laid and fired.

Automatic control is used in ordnance equipment for light loads (computers and indicators) and for heavy loads (gun mounts, turrets, fire control directors, and missile launchers). Light loads are usually driven by small electric motors; heavy loads usually require one of the following control units:

1. Electric hydraulic power drive.
2. Amplidyne power drive.

The electric-hydraulic power drives are powerful, reliable, and accurate. They are mainly used for training and elevating heavy loads or where strong starting and stopping forces are involved (on ammunition hoists and rammer mechanisms). The principal disadvantage of electric-hydraulic power drives is the constant maintenance they require.

The amplidyne power drives are also reliable, accurate, and require less maintenance. Amplidyne drives are superior to electric-hydraulic power drives for driving lighter loads, for instance, lighter mounts and directors. At present, the largest amplidyne power drive in use is the train unit for the Mk 39 5"/54 single mount.

The driving of a mount or director in response to a remote signal is divided into four general phases in the following sequence:

1. An order signal, received from a remote control station, is compared with the response signal or the position of the load (mount). The resulting signal is the error signal.

2. The error signal is amplified, to operate the controls of the power drive unit.

3. The power drive unit drives the load in the direction required to reduce the error signal to zero.

4. While the load is being driven, the response signal is continuously compared with the order signal.

TOPIC 2: ELECTRIC-HYDRAULIC POWER DRIVES AND THEIR OPERATION

You Are Now Going To Learn:

1. The purpose and advantage of electric-hydraulic power drives.
2. Operation of the train power drive for a 5"/38 twin mount.
3. Basic power drive components and their operation.

You Will Acquire Skill In:

1. Identifying the components of a power drive.
2. Tracing the operational sequence of a power drive.

Discussion Points For This Topic Are:

1. General information about electric-hydraulic power drives.
2. Operation of the train power drive.
3. Components of a power drive.
4. Modes of control.
5. Practical demonstration.
6. Review and summary.

ASSIGNMENT:

A. Reference publication:

1. Study NavPers 10186A, GMG 1 & C, Chapter 7.

INFORMATION AND DISCUSSION:

Electric-hydraulic power drives are used for moving naval gun mounts of all calibers, ranging from 40-millimeter mounts to 16-inch turrets. Electric-hydraulic power drive systems are extremely intricate; their complexity grows with the increase of automation.

The main advantage of using electric-hydraulic power drives is the positive control they provide at all acceleration and deceleration speeds for moving the extremely heavy units, including rotating turret structures which weigh hundreds of tons.

In this topic we will discuss a train power drive for a 5"/38 twin mount. This power drive consists of an indicator-regulator and a hydraulic variable-speed transmission.

The following text covers a simplified operational sequence of the train power drive.

The indicator-regulator receives an order signal from a remote control station, and a mount-position (response) signal from the gun. From these two signals, the indicator-regulator generates an error signal which is amplified and used to control the direction and speed of the hydraulic transmission.

The indicator-regulator is equipped with dials which indicate the value of the order and of the response signals.

The hydraulic speed transmission provides a variable-speed mechanical rotary-output in either direction. The transmission consists of the following major units:

1. Electric motor.
2. Reduction gears.
3. Hydraulic pump (A-end).
4. Hydraulic motor (B-end).

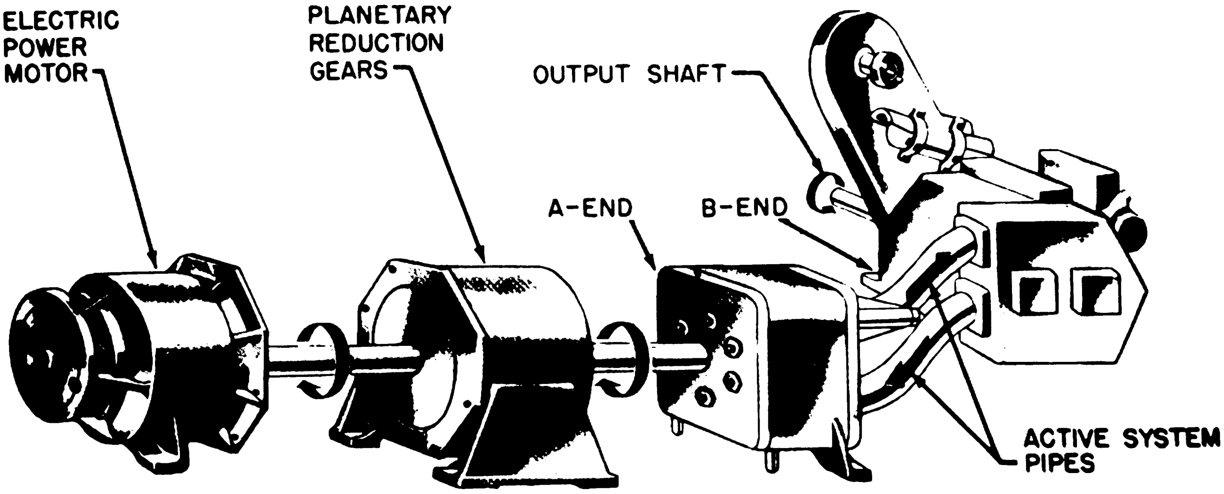
The A-end of the transmission is driven by a constant-speed, one-directional, AC 440-volt induction-type electric motor.

The reduction gear unit, located between the electric motor and the A-end, decreases the output speed of the electric motor and increases the power to drive the A-end.

The A-end hydraulically drives the B-end, and the B-end mechanically, through its gearing, trains or elevates the mount. The direction or extent of motion in train or elevation is controlled by the error signal applied to the A-end by the indicator-regulator.

The train power drive system has four methods of control:

1. Automatic.
2. Local.
3. Hand.
4. Manual.



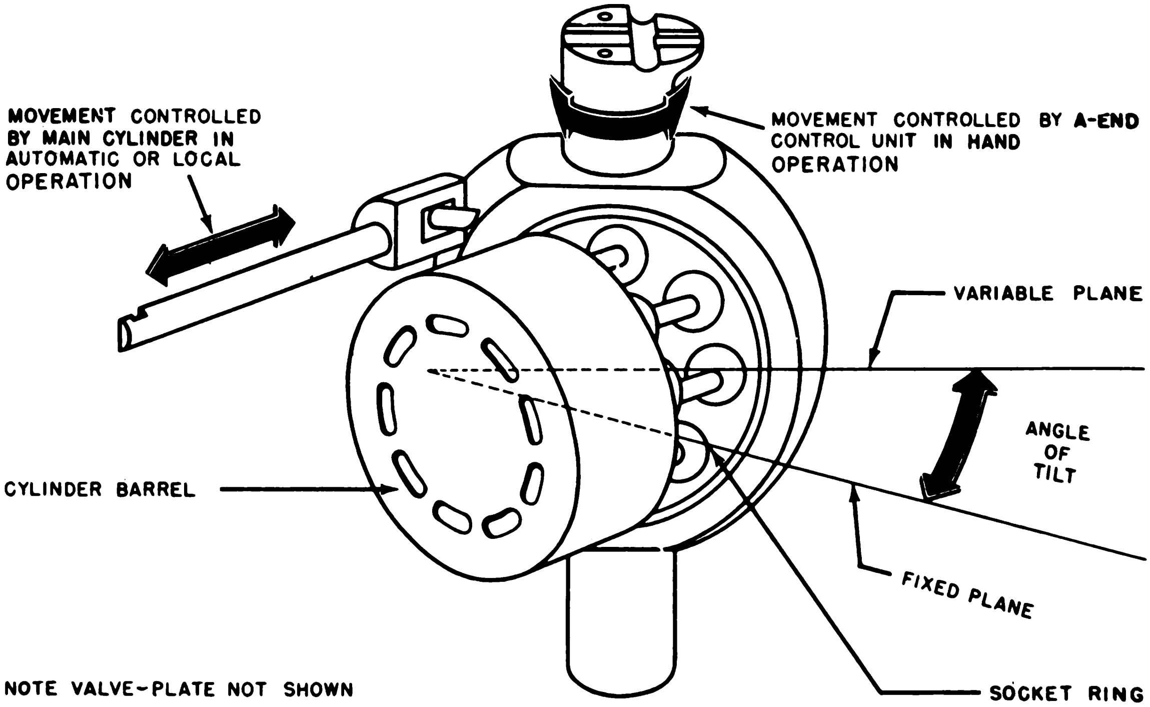
13-2. HYDRAULIC SPEED TRANSMISSION

The desired control method is selected by the control-selector lever at the trainer's station. A two-position (high and low) speed-selector lever is also located at the trainer's station.

During gun-laying in automatic control, the electrical order signal from a remote control station is received by a synchro-receiver, is compared with the mechanical response signal, and the resulting error signal is converted by the indicator-regulator into a mechanical signal which, in turn, is then converted into a hydraulical signal. (The mechanical response signal from the power drive gearing serves as input to the indicator-regulator where, together with the order signal, it helps to generate the error signal.)

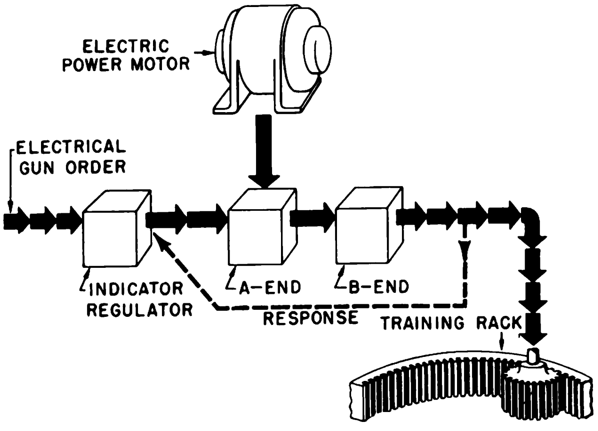
The hydraulic signal is amplified and then used to tilt the A-end, thus causing the power drive to follow the order signal.

When the gun position approaches synchronization with the gun-order signal, the error signal decreases


MOVEMENT CONTROLLED BY MAIN CYLINDER IN AUTOMATIC OR LOCAL OPERATION
MOVEMENT CONTROLLED BY A-END CONTROL UNIT IN HAND OPERATION
VARIABLE PLANE
ANGLE OF TILT
CYLINDER BARREL
FIXED PLANE
NOTE VALVE-PLATE NOT SHOWN
SOCKET RING

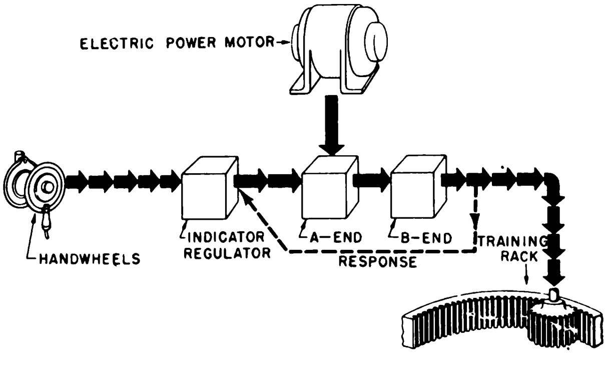
13-3. A-END, VARYING TILT ANGLE

until it becomes approximately zero.



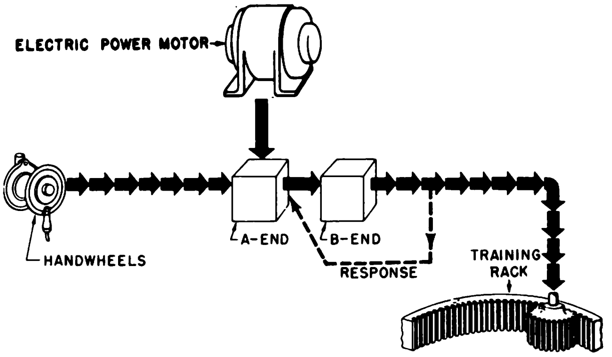
13-4. POWER DRIVE, SEQUENCE OF OPERATIONS IN AUTOMATIC CONTROL

In local control, the order signal is transmitted by means of the trainer's handwheels (not by a remote station) to the indicator-regulator which compares the order signal with the response signal and transmits the resulting error signal to the A-end.



13-5. POWER DRIVE, SEQUENCE OF OPERATIONS IN LOCAL CONTROL

In hand control, the trainer completely bypasses the indicator-regulator. The handwheels are geared to a mechanical follow-up system located in the A-end control unit. The A-end is powered by an electric motor. In response to the rotation of the handwheels, the A-end controls the B-end until the trainer's dial system indicates that the gun is at the position ordered. (Hand control is not available for all mounts.)



13-6. POWER DRIVE, SEQUENCE OF OPERATIONS IN HAND CONTROL

In manual control, the handwheels are geared directly to the training or elevating rack and bypass the entire electric-hydraulic system.

NOTE: The control arrangements of missile launchers and certain projector types are similar in many aspects to those used in conventional guns. According to their nature and design, guided missile launching systems must be capable of operating as accurately and dependably as the newest gun systems. The construction of the power drives used depends mainly upon the weight and other physical features of particular systems.

TOPIC 3: AMPLIDYNE FOLLOW-UP SYSTEM COMPONENTS AND OPERATION

You Are Now Going To Learn:

1. The basic components of an amplidyne follow-up system.
2. The operation of an amplidyne follow-up system.

You Will Acquire Skill In:

1. Identifying the components of an amplidyne follow-up system.
2. Tracing the operational sequence of train and elevation power drives on functional diagrams.

Discussion Points For This Topic Are:

1. Basic components of an amplidyne follow-up system:
    a. Receiver-regulator.
    b. Amplifier.
    c. Amplidyne motor/generator set.
    d. DC drive motor.
2. Operation of an amplidyne follow-up system.
3. Modes of control of an amplidyne power drive.
4. Practical demonstration.
5. Review and summary.

ASSIGNMENT:

A. Reference publication:

   1. Study NavPers 10186A, GM G 1 & C, Chapter 5.

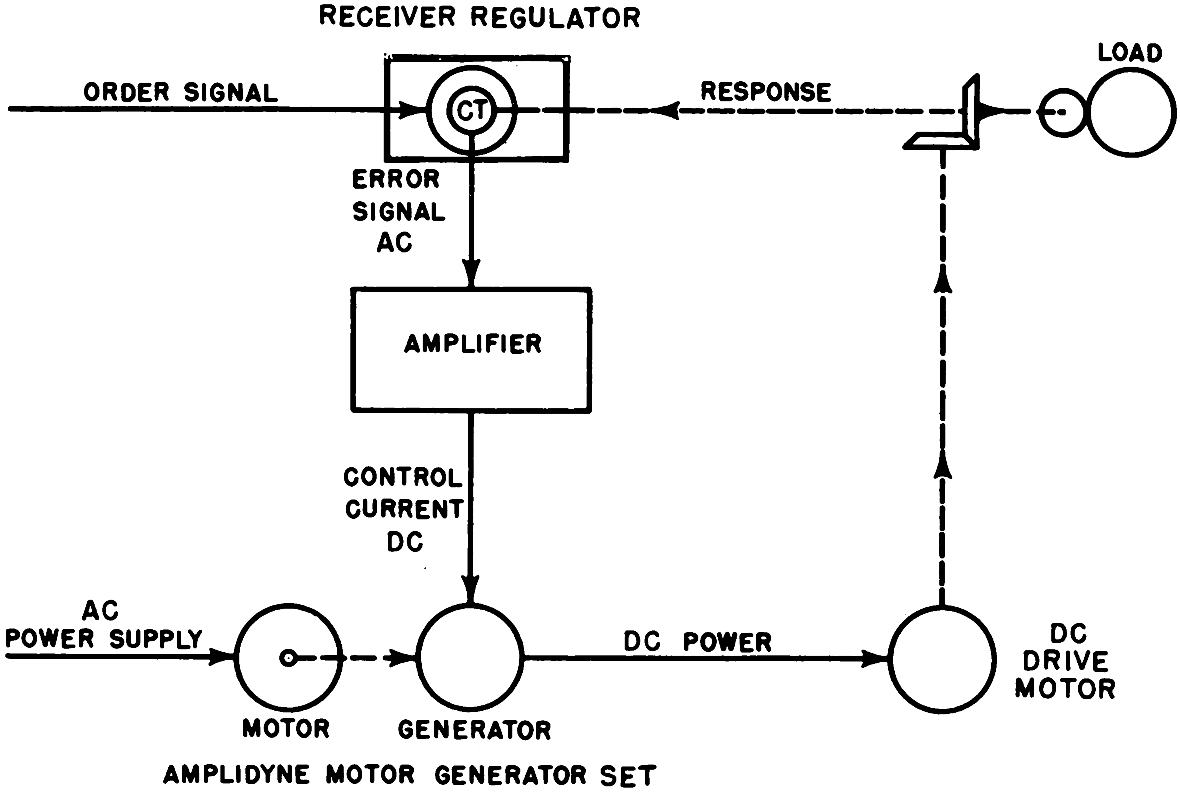
INFORMATION AND DISCUSSION:

An amplidyne follow-up system basically consists of the following four units:

1. Receiver-regulator.
2. Amplifier.
3. Amplidyne motor/generator set.
4. DC drive motor.

When the follow-up system is in automatic operation, each receiver-regulator (one for train and one for elevation) acts as "clearing house" for information, and gun-laying is completely automatic (requires no assistance from personnel on the mount).

The synchro control transformer, located in the receiver-regulator, receives the order signal which electrically indicates the required load-position. The actual load-position is determined by means of the rotor of the synchro control transformer



13-7. AMPLIDYNE FOLLOW-UP SYSTEM

which is rotated by the response shaft; the shaft, in turn, is geared to the load.

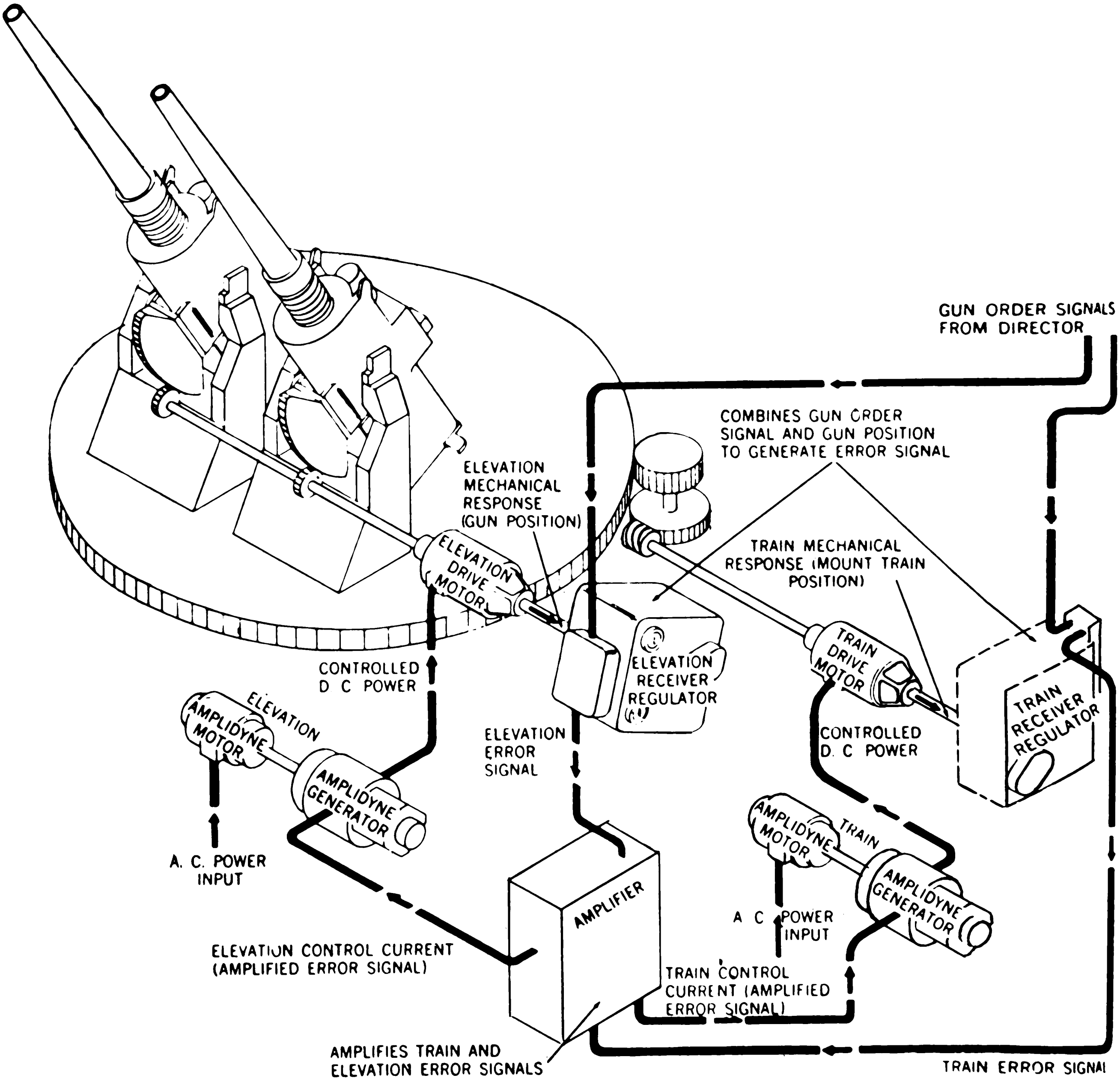
The actual load-position is compared by the synchro unit with the position ordered. The angular difference between the two positions constitutes the error.

When the actual load-position corresponds to the ordered position, the synchro unit performs no action; when the load-position does not correspond to the ordered position, the synchro unit generates an electrical signal which is called the error signal. The error signal is then transmitted to the amplifier.

The error signal, by means of its electrical characteristics, indicates the extent and direction of the error.

The amplifier amplifies the error signal and converts it from AC to DC, to energize the field windings of the amplidyne generator.

The amplidyne motor/generator set is basically a large power amplifier. Its power output depends on the strength of its control-field current. The strength of the control-field current depends on the extent of the error received from the amplifier. Therefore, more


GUN ORDER SIGNALS FROM DIRECTOR
COMBINES GUN ORDER SIGNAL AND GUN POSITION TO GENERATE ERROR SIGNAL
ELEVATION MECHANICAL RESPONSE (GUN POSITION)
TRAIN MECHANICAL RESPONSE (MOUNT TRAIN POSITION)
ELEVATION DRIVE MOTOR
TRAIN DRIVE MOTOR
ELEVATION RECEIVER REGULATOR
TRAIN RECEIVER REGULATOR
CONTROLLED D C POWER
CONTROLLED D. C POWER
ELEVATION ERROR SIGNAL
ELEVATION AMPLIDYNE MOTOR
AMPLIDYNE GENERATOR
A. C. POWER INPUT
TRAIN AMPLIDYNE MOTOR
AMPLIDYNE GENERATOR
A C POWER INPUT
AMPLIFIER
ELEVATION CONTROL CURRENT (AMPLIFIED ERROR SIGNAL)
TRAIN CONTROL CURRENT (AMPLIFIED ERROR SIGNAL)
AMPLIFIES TRAIN AND ELEVATION ERROR SIGNALS
TRAIN ERROR SIGNAl

13-8. ELEVATION AND TRAIN POWER DRIVES, AUTOMATIC CONTROL

power is applied to the DC drive motor for a large error signal than for a small one.

The DC drive motor, located on the mount, trains or elevates the guns by means of its gearing.

The direct current to operate the drive motor is supplied by the amplidyne generator. The rotation direction of the motor depends on the polarity of the output of the amplidyne generator. The direction of this output, in turn, depends on the direction of the error signal. Consequently, the motor moves the load in proper direction to reduce the error.

As long as there is an order signal present, there also is an error signal. (Without an error signal, no power would be supplied to the drive motor to move the load.)

Because of the immense amplification capability of the amplidyne, the necessary power to drive the motor can be provided even when the error is extremely small.

Under normal operating conditions, the error of a load following a moving order signal is frequently so small that it is almost negligible, and the load acts as if it were geared to the order signal.

When the power drive is operated in local control, the receiver-regulator functions differently than in automatic control: Its synchro unit merely generates a signal indicating the speed and direction of the moving load and transmits this signal to the control amplifier.

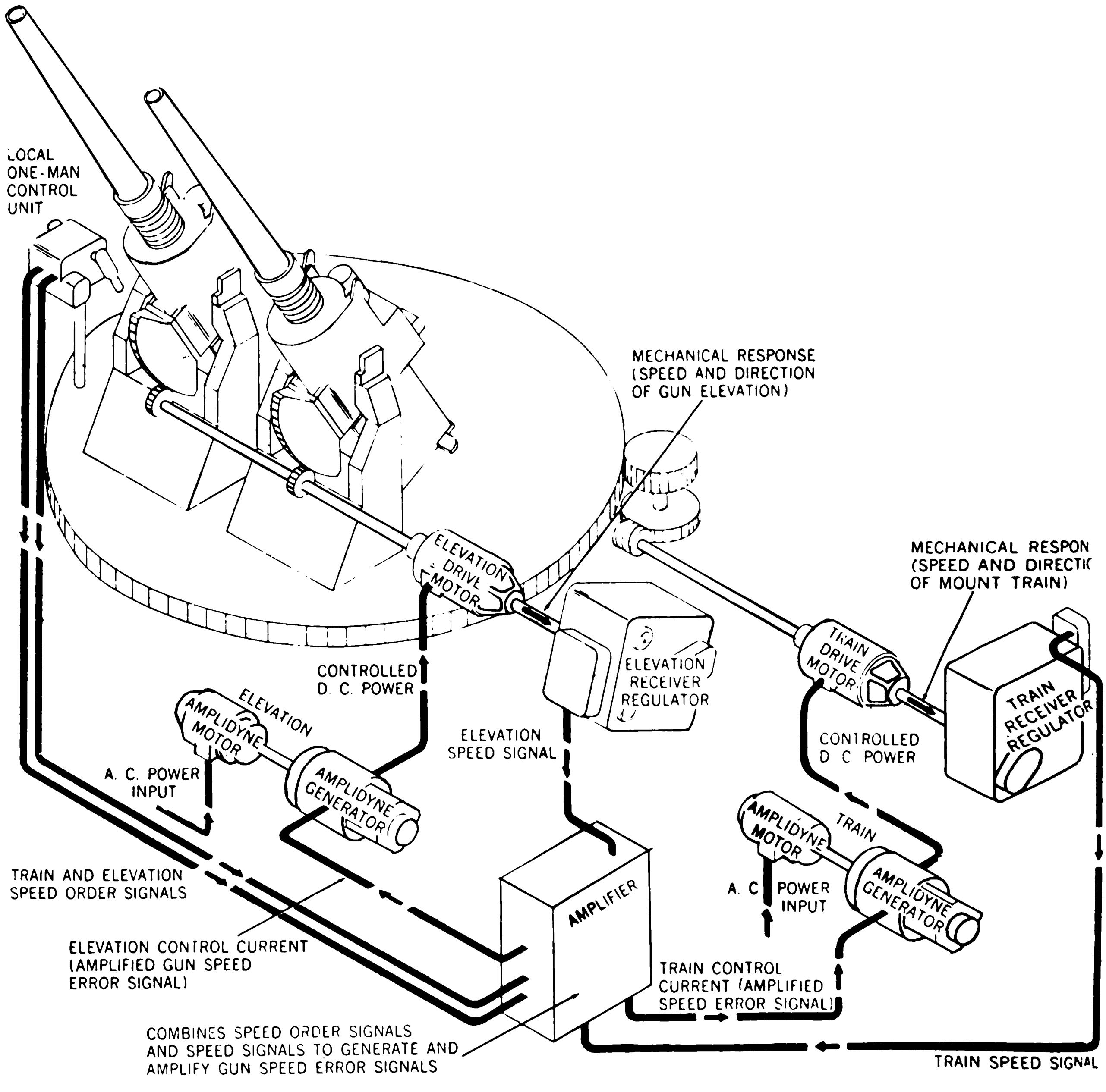
In addition to the load-speed response-signal, the control amplifier receives a speed-order signal from one of the two one-man control stations in the gun mount and constantly compares the actual load-speed with the speed ordered. When these two speeds are alike, the control amplifier performs no action; but when they do not agree, the amplifier generates an error signal which indicates the extent of the error and the direction in which the drive motor must be rotated to reduce the error.

Since the error signal is very weak, it is amplified by the control amplifier and the amplidyne, to keep the load moving at the ordered speed.

When the speed order requests stopping of the load, the load signal becomes the error signal which now is proportionally opposite-phase (or opposite direction) to the speed-order signal. The error signal then starts declining as the load is coming to rest.

When the load is stopped, the error signal becomes zero, and the drive motor does not receive any power.

For the operation of the elevation and train power drives in local control, refer to illustration on following page.


LOCAL ONE-MAN CONTROL UNIT
MECHANICAL RESPONSE (SPEED AND DIRECTION OF GUN ELEVATION)
ELEVATION DRIVE MOTOR
MECHANICAL RESPON (SPEED AND DIRECTI OF MOUNT TRAIN)
TRAIN DRIVE MOTOR
ELEVATION RECEIVER REGULATOR
TRAIN RECEIVER REGULATOR
CONTROLLED D. C. POWER
ELEVATION
AMPLIDYNE MOTOR
A. C. POWER INPUT
AMPLIDYNE GENERATOR
ELEVATION SPEED SIGNAL
CONTROLLED D C POWER
TRAIN
AMPLIDYNE MOTOR
A. C POWER INPUT
AMPLIDYNE GENERATOR
TRAIN AND ELEVATION SPEED ORDER SIGNALS
ELEVATION CONTROL CURRENT (AMPLIFIED GUN SPEED ERROR SIGNAL)
AMPLIFIER
TRAIN CONTROL CURRENT (AMPLIFIED SPEED ERROR SIGNAL)
COMBINES SPEED ORDER SIGNALS AND SPEED SIGNALS TO GENERATE AND AMPLIFY GUN SPEED ERROR SIGNALS
TRAIN SPEED SIGNAL

13-9. ELEVATION AND TRAIN POWER DRIVES, LOCAL CONTROL

AMPLIDYNE FOLLOW-UP SYSTEM
COMPONENTS AND OPERATION

TOPIC 4: SHIPBOARD TESTS AND TEST EQUIPMENT

You Are Now Going To Learn:

1. The purpose of tests.
2. The miscellaneous casualties encountered in automatic control equipment.
3. The construction features and functions of test equipment and error recording devices.

You Will Acquire Skill In:

1. Using the test equipment and error recording devices.

Discussion Points For This Topic Are:

1. Purpose of tests.
2. Miscellaneous casualties and their effects.
3. Test equipment.
4. Error recording.
5. Practical demonstration.
6. Review and summary.
7. Section review.
8. Written test.

ASSIGNMENT:

A. Reference publications:
    1. Optional reading list:
        a. OD 4166.
        b. OP 2809.

INFORMATION AND DISCUSSION:

Routine tests are performed daily to discover any malfunctions of the automatic control equipment. These tests include operation of all ordnance power equipment and testing of safety equipment, such as automatic limit stops, firing cutouts, brakes, and power failure devices.

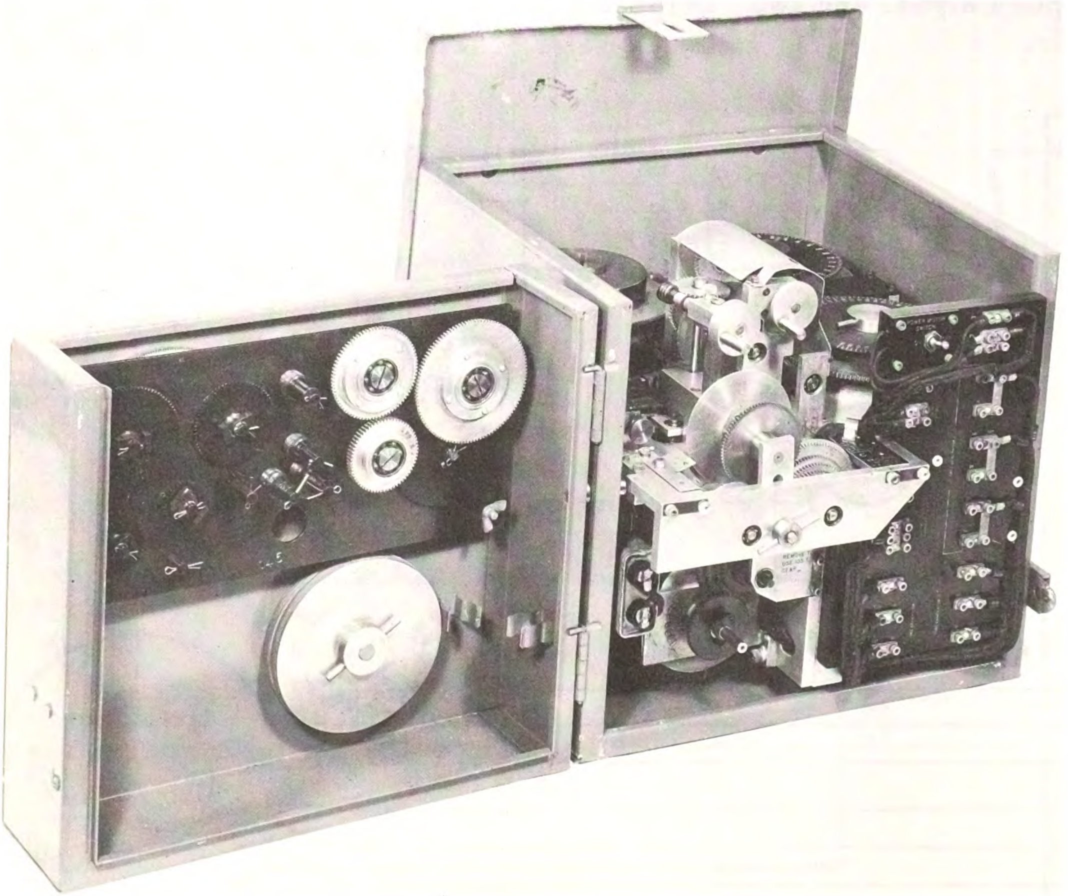
A transmission check is another daily test. It consists of operating the gun mount, turret, or launcher from the applicable remote control stations to ensure proper automatic operation.

Excessive oscillation (hunting) or excessive sluggishness in the operation of a power drive usually indicates that a component is not functioning properly or that an adjustment to the equipment is necessary. These obvious equipment malfunctions are readily identified; however, for extensive testing to determine the dynamic accuracy of the response of a mount to a remote order signal, special instruments, such as dummy directors and error recorders, are used.

Dummy directors and error recorders are portable instruments designed to perform dynamic accuracy tests on power drives in automatic control. These tests are performed quarterly, during shipyard overhaul, and when it is suspected that the equipment is not functioning properly.

A dummy director introduces an order signal to a power drive. This signal either may be one-directional (constant velocity) or may roll between a predetermined number of degrees (simple harmonic).

An error recorder is an instrument for measuring and recording the instantaneous difference (error) between the dynamic order signal and the actual position (response) of the power drive equipment being tested.



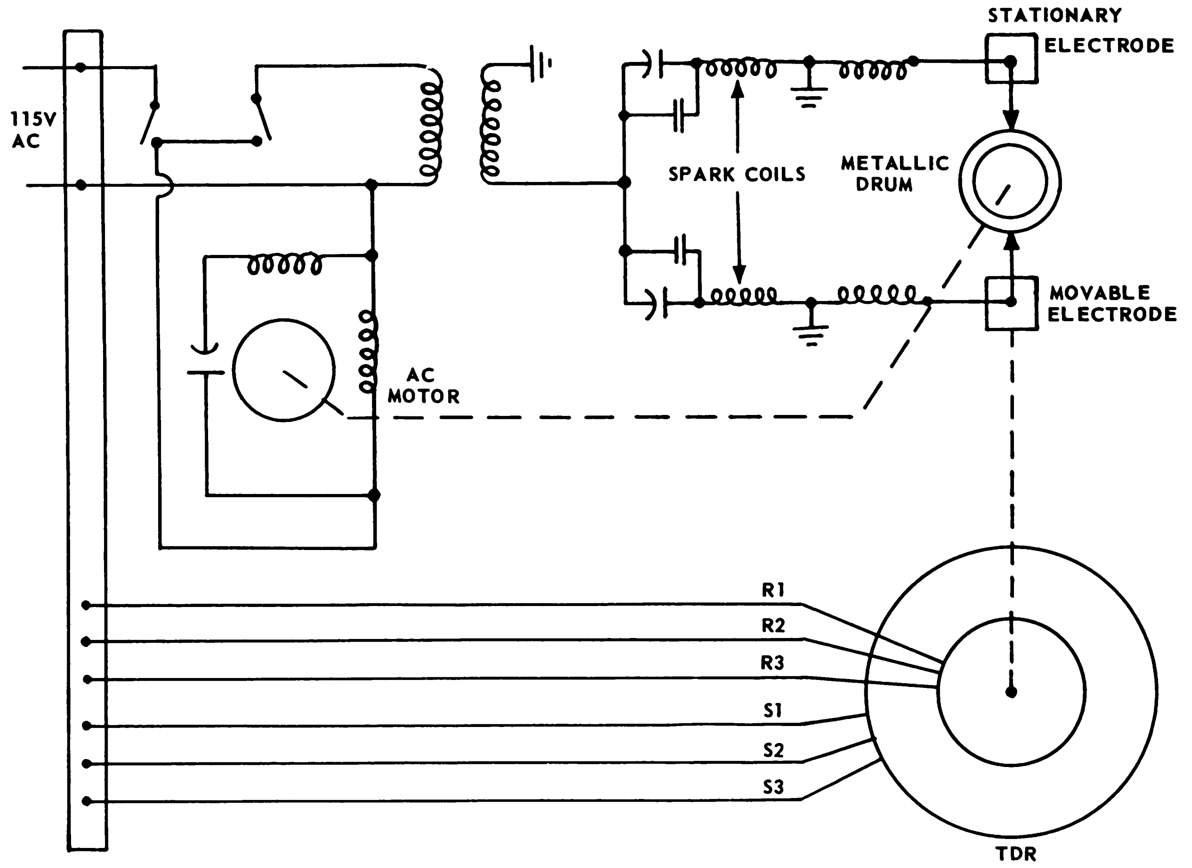
13-10. DUMMY DIRECTOR MK 1 MOD 3

Several types of dummy directors and error recorders have been designed for use on gun mounts and turrets. The more common types are dummy director Mk 1 Mod 3 and error recorder Mk 1 Mod 3. These two instruments are normally used together as a test set and are retained aboard repair ships and in Navy shipyards.

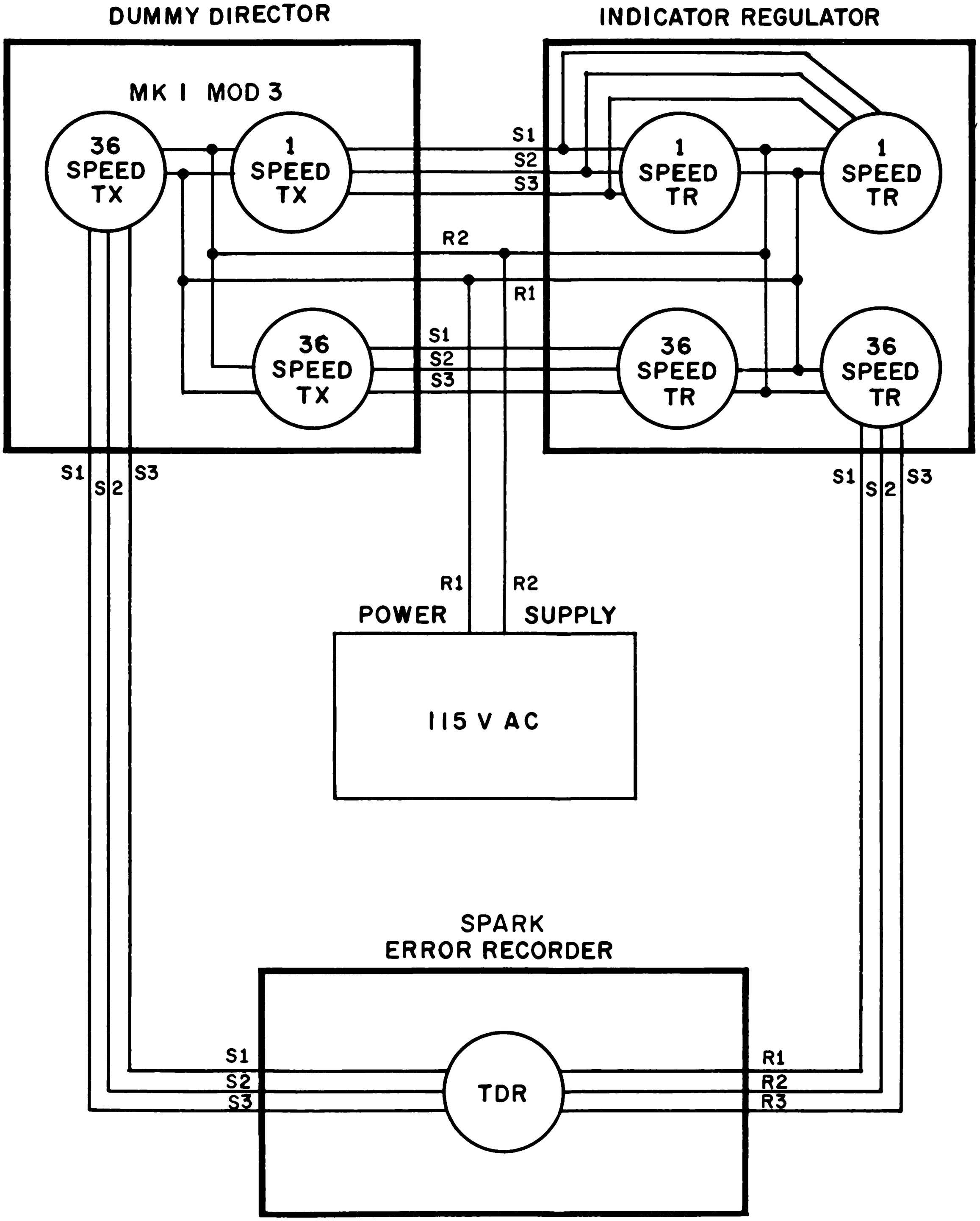
Dummy director Mk 1 Mod 3 consists of a constant-speed power motor, a ball-type integrator, and three synchro transmitters. The transmitters are geared to produce a 1-speed signal and two 36-speed signals.

One of the 36-speed transmitters and the 1-speed transmitter are connected to the power drive being tested; the other 36-speed transmitter is connected to the error recorder, as shown in illustration #13-12 on the following page. The speed at which the dummy director drives and the amplitude of the roll in degrees are controlled by means of change-gears. (Instructions for meshing these change-gears to obtain various amplitudes are provided in tables, which are located in the cover of the instrument, and in OD 4166.)

The Mk 1 Mod 3 error recorder



13-11. SPARK ERROR RECORDER MK 1 MOD 3, SCHEMATIC DIAGRAM



13-12. DYNAMIC ACCURACY TEST EQUIPMENT, WIRING DIAGRAM FOR 5"/38 TWIN MOUNT consists of a synchro differential receiver, two vibrator-type spark-coils, two electrodes (one movable and one stationary), and a motor-driven metallic drum. The synchro differential normally receives the order signal on its stator windings and the position (response) signal on its rotor windings. The rotor of the differential is mechanically connected to the movable electrode.

During tests a strip of paper passes between the drum and the two electrodes. When the spark coils are energized, sparks jump between the electrodes and the metallic drum, producing small burn spots on the paper.

When the order signal and response signal on the synchro differential agree, the differential rotor remains stationary, and two straight, equally spaced rows of spots appear on the tape. However, if the two signals do not agree (some error is always present), the rotor of the synchro differential is displaced an amount proportional to the error, and the spots are displaced by the movable electrode.

The amount of error can be determined by using the straight row of spots made by the stationary electrode as a reference. A transparent scale is provided to measure the amplitude of the error. (Typical samples of spark-type error recording traces are shown in illustration #13-13 on the following page.)

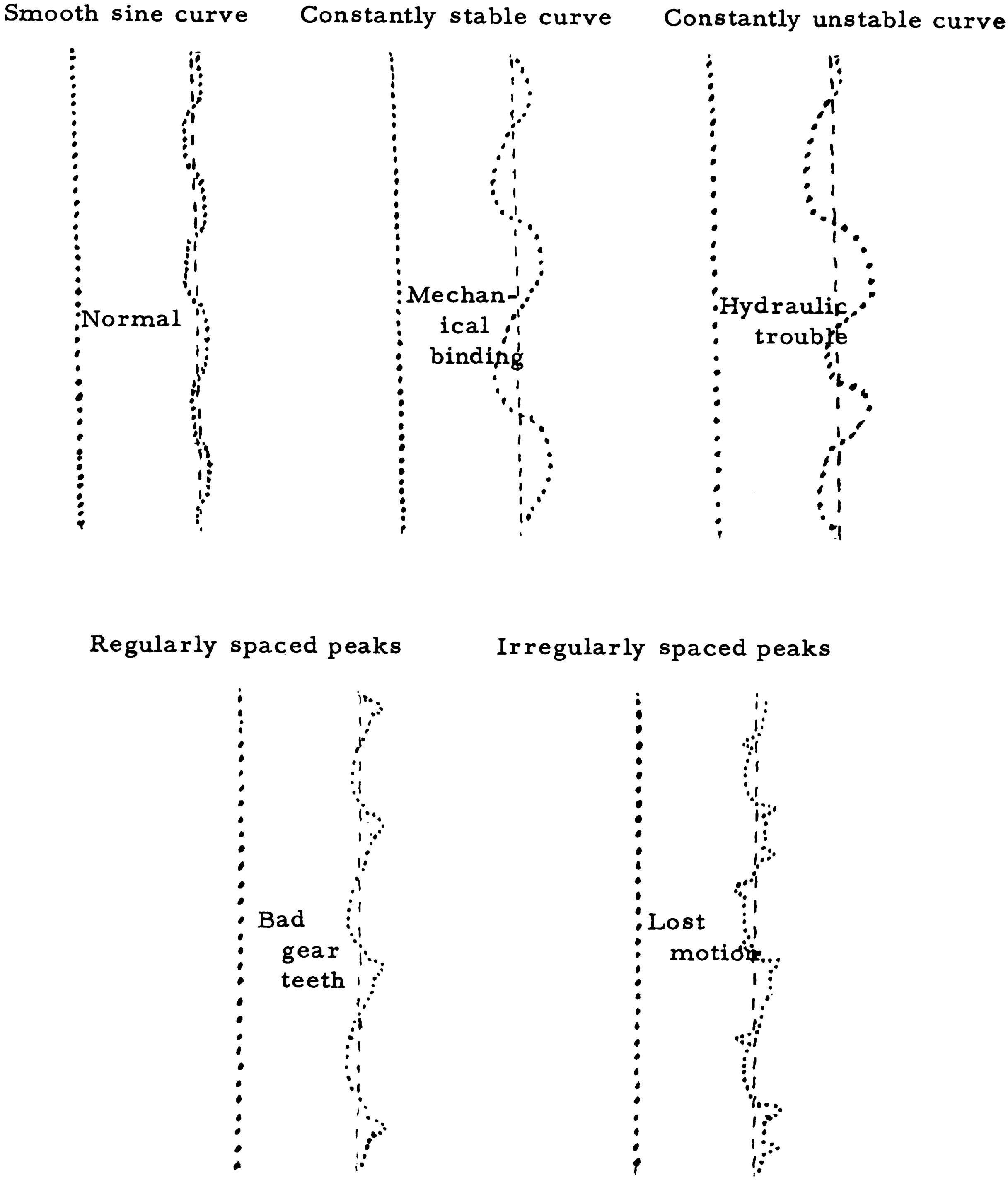
Dummy director Mk 1 Mod 6 and a magnetic oscillograph error recorder have been used for instrumentation of missile launching systems. These instruments are now normally retained at naval shipyards. However, they were originally issued as standard test equipment for missile launching systems and may still be found aboard some ships of the fleet.

Dummy director Mk 1 Mod 6 is similar in construction and appearance to the Mk 1 Mod 3 unit, except that 400-cycle synchros are used in place of the conventional 60-cycle synchros. This new director also has a velocity tachometer generator that transmits a DC voltage proportional to the speed of the order signal.

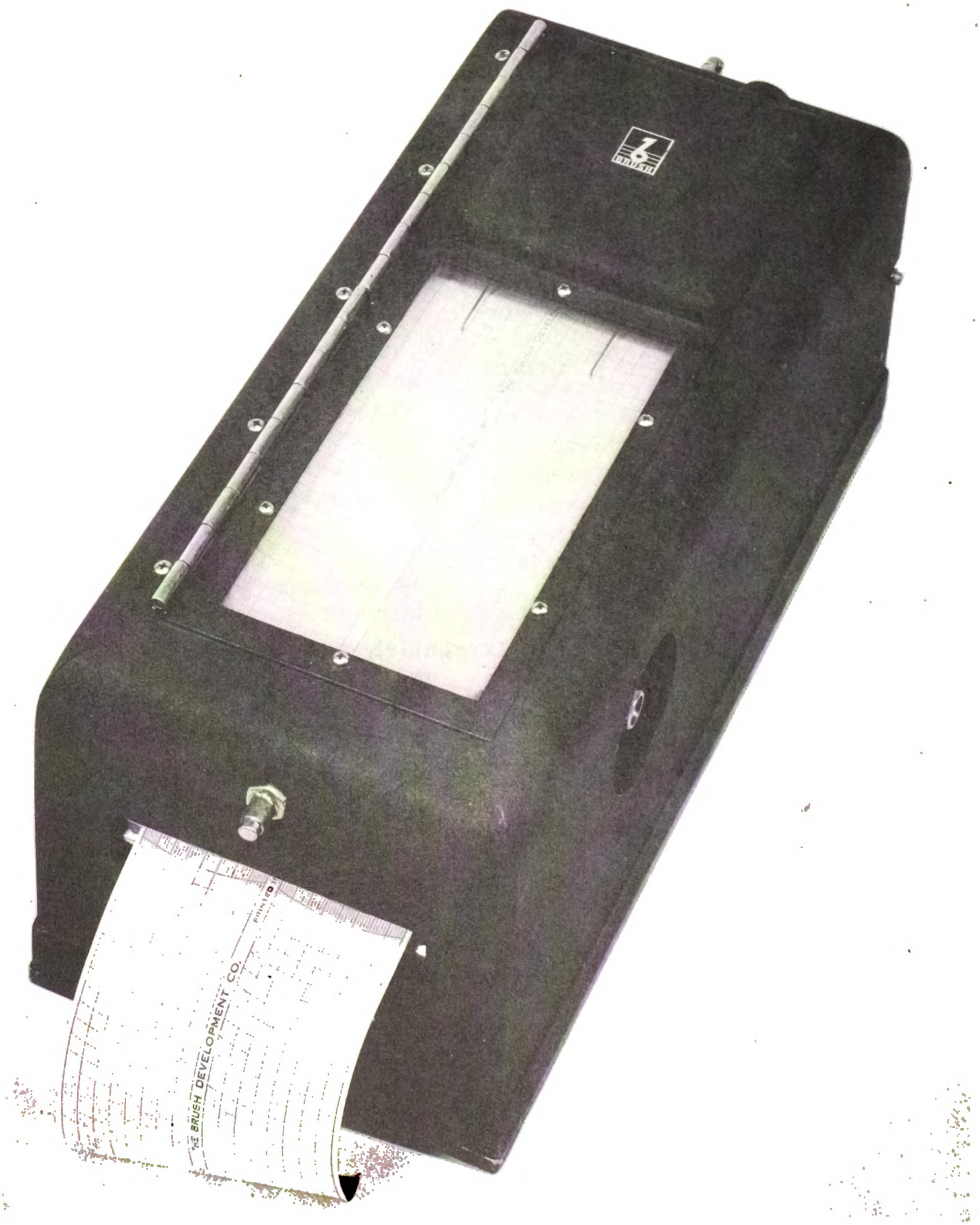
Error recording by means of a magnetic oscillograph (direct writing on graph paper) can be performed by using either a stylus which writes with ink or an electric stylus which writes on special magnetic paper.

The magnetic oscillograph can be equipped with two magnetically powered pens which simultaneously record information obtained from two channels.

In conjunction with the magnetic oscillograph, a limiter-demodulator unit must be used, to calibrate, attenuate, balance, limit, and filter the error signal before it is fed into the recorder. When both channels



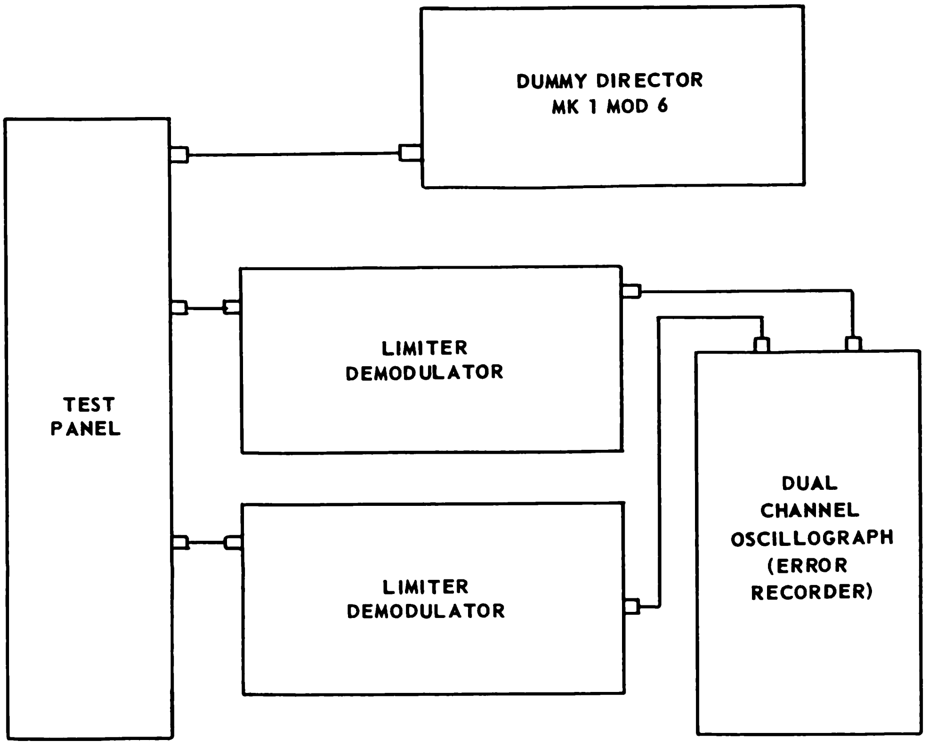
13-13. SPARK METHOD, SAMPLES OF ERROR RECORDINGS (POSSIBLE CASUALTIES INDICATED)



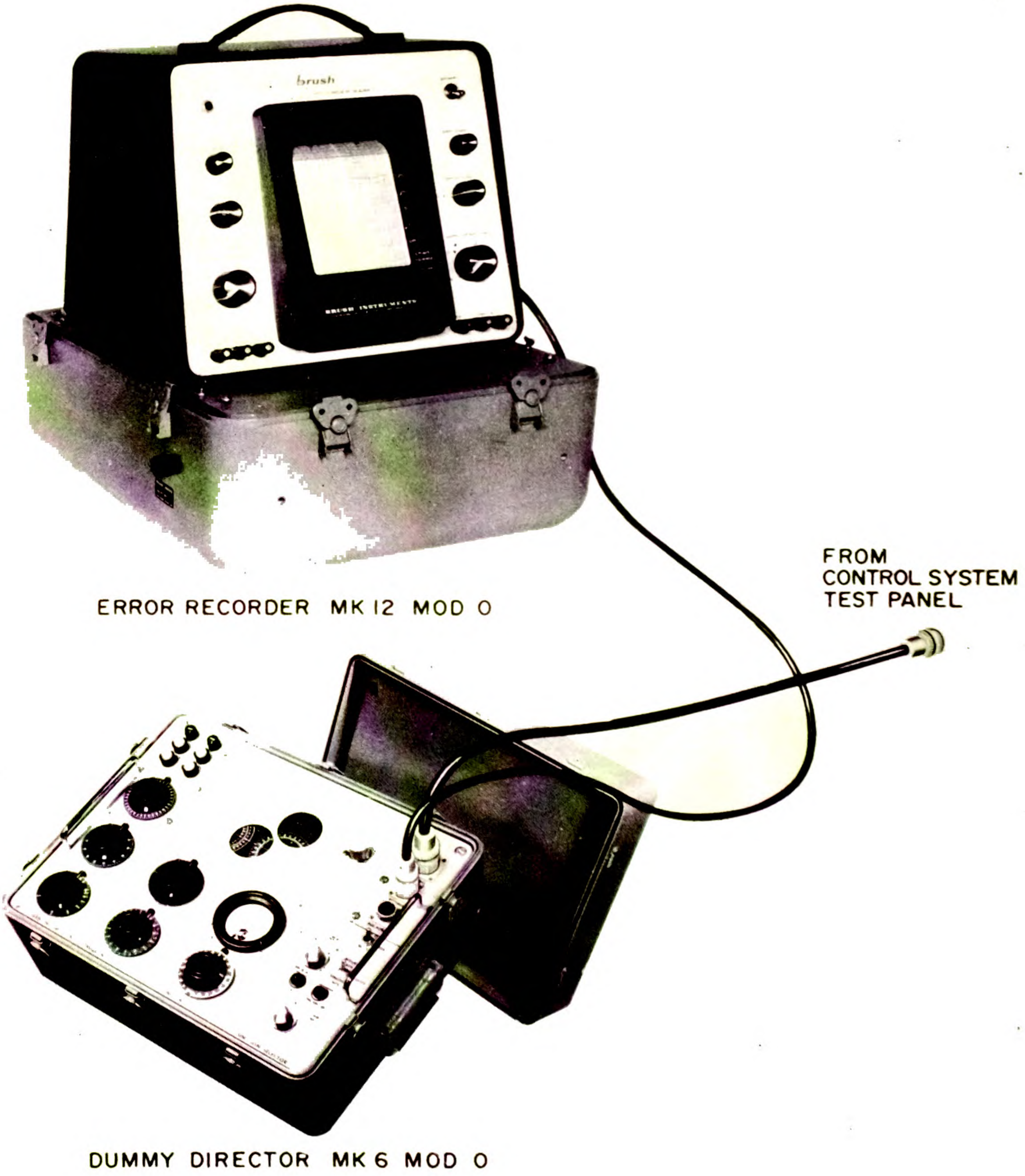
13-14. MAGNETIC OSCILLOGRAPH (ERROR RECORDER) of a magnetic oscillograph are used, it is necessary to have a separate limiter-demodulator for each channel.

The instruments that are necessary for error recording on a missile launching system are connected into a test panel, as shown in illustration #13-15 below. The test panel is a permanent installation which is part of the guided missile launching system. Switches on the test panel enable the operator to perform various system tests without changing the normal wiring between the fire-control system and the missile launching system. Special receptacles are also provided in the test panel to receive the cables from the test instruments. Other special test instruments (not shown in illustration #13-15) are also used in connection with the test panel.

New test equipment consisting of dummy director Mk 6 Mod 1 and error recorder Mk 12 Mod 0 (refer to illustration #13-16) has been designed primarily for shipboard use in testing the launcher power drives for ASROC and missile launching systems. This new test set is not as accurate as dummy director Mk 1 Mod 6 and its associated in-



13-15. SHIPBOARD TEST SETUP, DUMMY DIRECTOR MK 1 MOD 6 AND ASSOCIATED TEST INSTRUMENTS


ERROR RECORDER MK 12 MOD 0
FROM CONTROL SYSTEM TEST PANEL
DUMMY DIRECTOR MK 6 MOD 0

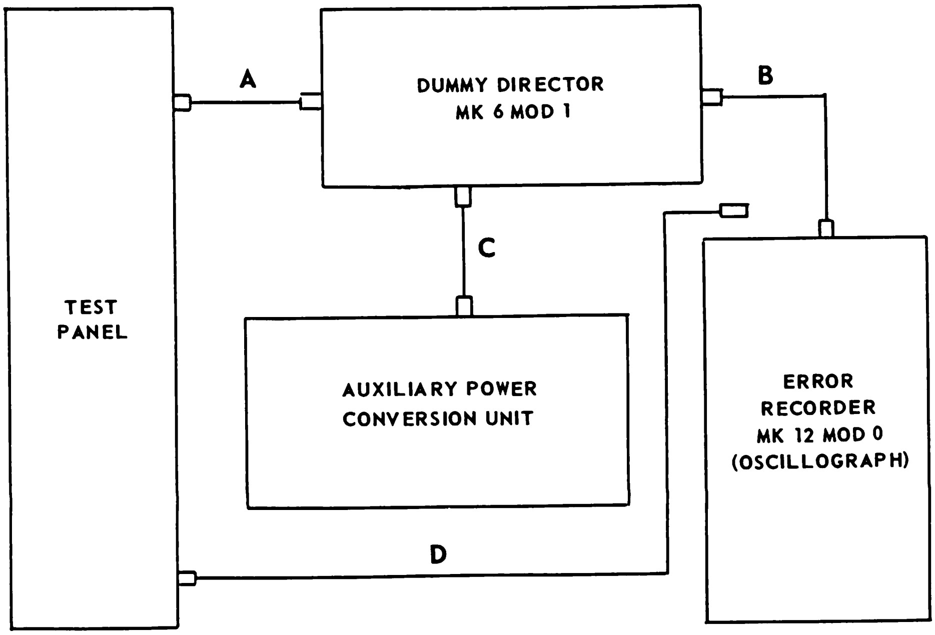
13-16. SHIPBOARD ERROR RECORDING TEST SET struments, but it does perform an acceptable shipboard dynamic test.

Dummy director Mk 6 Mod 1, housed in a portable aluminum case, requires 115-volt, 400-cycle, AC power for operation. The power is supplied from the system test panel through a cable stored in the director case.

A director servo drive motor with transistor and potentiometer control drives two synchro transmitters for 1- and 36-speed order signals, together with a 36-speed synchro control transformer (CT) for error detection purposes. The servo motor also drives a DC tachometer for generation of the velocity signal required by some power drives.

The Mk 6 Mod 1 director also has an auxiliary servo drive motor, with transistor and potentiometer control similar to that of the main servo drive motor, for generation of oscillating signals to produce simple harmonic motion control of the main servo drive motor.

Error recorder Mk 12 Mod 0 is a modified, dual-channel, commercial Brush Instrument Company recorder, Mark II. This instrument, housed in a portable case, requires 115-volt, 60-cycle, AC power which


TEST PANEL
A
DUMMY DIRECTOR MK 6 MOD 1
B
C
AUXILIARY POWER CONVERSION UNIT
ERROR RECORDER MK 12 MOD 0 (OSCILLOGRAPH)
D

13-17. SHIPBOARD TEST SETUP, DUMMY DIRECTOR MK 6 MOD 1 AND ERROR RECORDER MK 12 MOD 0 normally is supplied from the launching system test panel. Simple adjustment and chart speed controls are located on the front panel, permitting convenient change of chart paper. In addition to the two chart-recording pens, the recorder also includes two event marker pens which are individually operated through remote control circuits. The recorder may also be used for time recordings of various launching system sequence operations by using the alternate connection of cable D (refer to illustration #13-17 on the preceding page).

An auxiliary power conversion unit, shown in illustration #13-17, is included with this new test set for use on equipment that is limited to 60-cycle power.

As previously mentioned, this new recording equipment is intended primarily for convenient shipboard dynamic testing of launcher train and elevation power drives. Immediately after satisfactory completion of the installation tests for each particular launcher (installation tests are performed by the installing yard or manufacturer), a complete set of launcher performance records should be produced by means of dummy director Mk 6 Mod 1 and error recorder Mk 12 Mod 0. These records are to be retained on board ship for reference and comparison with subsequent periodic shipboard test records produced by this recording equipment. Similar procedures should be followed in connection with overhaul and repairs affecting the launcher power drives.

QUIZ SHEETS:

1. What is an error signal?

____

____

____

2. State the main advantage of using automatic control for weapon systems.

____

____

____

3. For heavy loads, amplidyne power drives are superior to electric-hydraulic power drives.

True ________ or False ______.

4. In electric-hydraulic power drives, the error signal is amplified electrically.

True ______ or False ________.

5. What are the functions of reduction gears on electric-hydraulic power drives?

____

____

____

6. The speed of the B-end is determined by the

   a. Electric motor.
   b. A-end tilt.
   c. Response.
   d. Load.

7. In hand control, the A-end is

   a. Hydraulically tilted.
   b. Electrically tilted.
   c. Mechanically tilted.
   d. Not tilted at all.

8. In an amplidyne power drive, a mount is driven directly by a/an

   a. AC motor.
   b. DC motor.
   c. Amplidyne.
   d. Servo.

9. The error signal indicates the ______________ and the _________ of the error.

10. Which mode of control is provided by the one-man control station?

____

____

11. In local control, the amplifier receives from the amplidyne receiver-regulator a/an

   a. Order signal.
   b. Error signal.
   c. Load-position signal.
   d. Load-speed signal.

12. What is the purpose of transmission checks?

____

____

____

13. How often should the emergency stop devices be checked?

____

14. When are dummy-director tests and error-recorder tests performed?

____
____
____

15. What is the purpose of the dummy-director and error-recorder tests?

____
____
____

16. How does the limiter-demodulator affect the error signal?
a. ________________________________
b. ________________________________
c. ________________________________
d. ________________________________
e. ________________________________

17. For dynamic accuracy tests using dummy directors Mk 1 Mod 3 and Mk 1 Mod 6, the speed of the order signal is determined by which of the following?

a. Change-gears.
b. Servo motor.
c. Synchro transmitter.
d. Synchro differential receiver.

18. A complete set of records of a dynamic accuracy test should be retained aboard ship for reference purposes.

True ________ or False ________

19. Which of the following dummy directors will normally be used by ship's force to conduct dynamic accuracy tests on a missile launcher?

a. Mk 1 Mod 3.
b. Mk 1 Mod 6.
c. Mk 3 Mod 1.
d. Mk 6 Mod 1.

20. In the dummy director Mk 1 Mod 3, which synchro(s) transmit(s) the order signal(s) to the error recorder?

a. 1-speed.
b. 1-speed and 36-speed.
c. 36-speed.
d. 2-speed and 36-speed.

21. When error recording tests are being made, which possible casualty is indicated by regularly spaced peaks?

____
____
____

22. When error recording tests are being made, which possible casualty is indicated by a constantly unstable curve?

____
____
____

Accuracy of notes checked by instructor:

Date ______________________________

Trainee's initials ___________________

Section 14

RECEIVER REGULATORS

ASSIGNMENT-DISCUSSION-QUIZ SHEETS

Topic No.	Topic Title	Page
1.	Introduction to a Receiver Regulator	240
2.	Location, General Arrangement, and Functions of Components	246
3.	Train Power Drive Control System	260
4.	Primary and Stroke Servo Systems	272
5.	Train Velocity and Integration Systems	290
6.	Launcher Synchronizing Indication System	302
7.	Limit Stop and Automatic Tracking Cutout Systems	306
8.	Other Receiver Regulator Models	324

TOPIC 1: INTRODUCTION TO A RECEIVER REGULATOR

You Are Now Going To Learn:

1. The functions of a receiver regulator.

2. The introduction to the receiver regulator Mk 45.

Discussion Points For This Topic Are:

1. The purpose of receiver regulators.

2. Receiver regulator design characteristics.

3. Location of the receiver regulator Mk 45.

4. Power-drive servo-loop systems.

5. Receiver-regulator servo systems.

6. Review and summary.

INFORMATION AND DISCUSSION:

A receiver regulator is the component of a mount or launcher power drive that receives order signals from a remote or local station, compares these signals with the train or elevation positions, and generates error signals to control the movements of the power drive.

Most of the receiver regulators used on launcher power drives associated with missile launching systems are similar in design. However, gun mount and turret power-drive regulators differ in construction and design from launcher power-drive regulators. Because of the special characteristics of gun mount and turret regulators, the nomenclature associated with the instruments often varies.

The following description is provided to clarify the various design characteristics of receiver regulators.

1. Receiver regulator--Used primarily on turret and missile launcher power drives.

2. Indicator receiver-regulator, also referred to as indicator regulator--Functions like a receiver regulator, except that an indicating section has been incorporated into the instrument. The indicator receiver-regulator is used on the 5"/38 gun mount power drives.

3. Indicator--A separate instrument used to indicate the director and gun positions. When used in a turret, the indicator is located at the pointer and trainer stations, while the receiver regulator is located on a lower deck.

4. B-end synchro unit--Primarily used on 40-mm gun mounts, rocket launchers, and projector power-

drives, performs the basic functions of a receiver regulator; however, it is usually simpler in design than a receiver regulator.

The information contained in the remainder of this section, unless otherwise specified, will pertain to the train receiver regulators used on the launcher Mk 5 which is associated with the missile launching system Mk 10. The differences between the regulators Mk 37 (for elevation) and Mk 45 (for train) are minor and will be pointed out in later topics.

The launcher receiver-regulator is part of the basic power-drive servo loop which also includes the following:

1. Hydraulic pump (A-end).

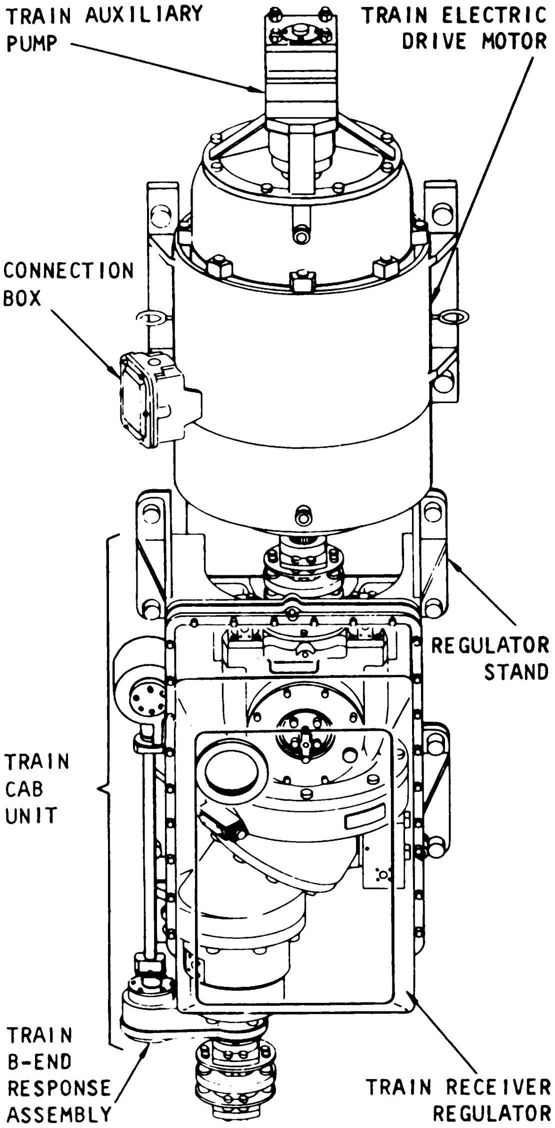
2. Hydraulic motor (B-end).

3. A-end and B-end response linkage.

The launcher receiver regulator is mounted on a stand, directly over the A- and B-ends (CAB unit), as shown in illustration #14-1.

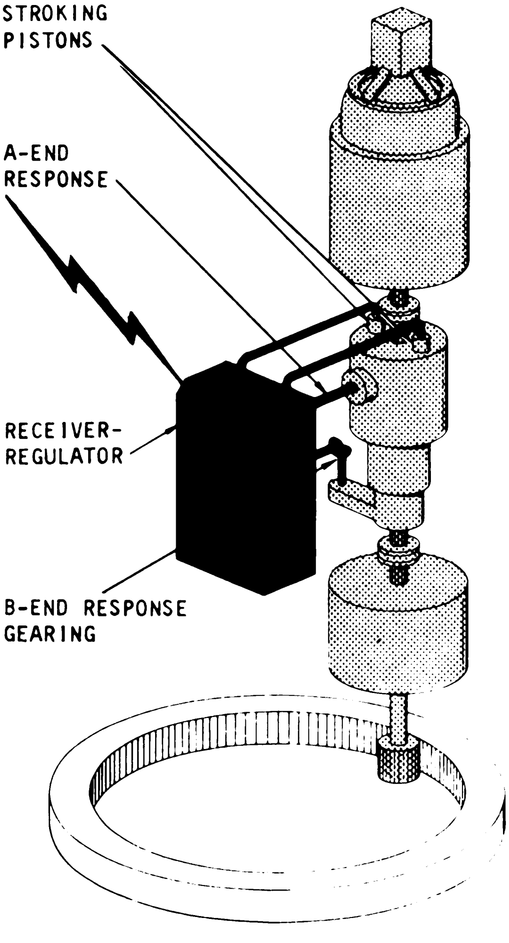
The power-drive servo-loop receives an electrical remote order signal on the stator windings of a bearing-mounted control transformer (CTB) located in the receiver regulator. The CTB compares the launcher position with the order signal and generates an electrical error signal. The error signal is converted by the regulator to a proportional hydraulic signal. The regulator utilizes the hydraulic signal to control the A-end output.

When the A-end receives an error signal, it starts tilting and displaces hydraulic fluid, thus causing the B-end to rotate. A mechanical tilt response-signal from the A-end



14-1. TRAIN POWER DRIVE, GENERAL ARRANGEMENT is fed back to the regulator. This response signal cancels the hydraulic error signal when the proper angle of tilt has been applied to the A-end.

When the B-end rotates, it drives the launcher, through a gear reduction unit, at the speed and in the direction determined by the error signal. A mechanical B-end response signal is fed back to the CTB stator in the receiver regulator. This response signal cancels the order signal when the order has been satisfied.



14-2. POWER-DRIVE SERVO-LOOP COMPONENTS

The components of the power-drive servo loop are shown in illustration #14-2.

Actually, four separate servo systems within the receiver regulator function together to control the position of the A-end tilt-plate during normal operation. Each servo system has its own feedback; therefore each can be considered as a servo loop. These four servo systems are:

1. Stroke servo system.
2. Primary servo system.
3. Velocity servo system.
4. Integration system.

The stroke servo system is used by the other servo systems to control the A-end tilt.

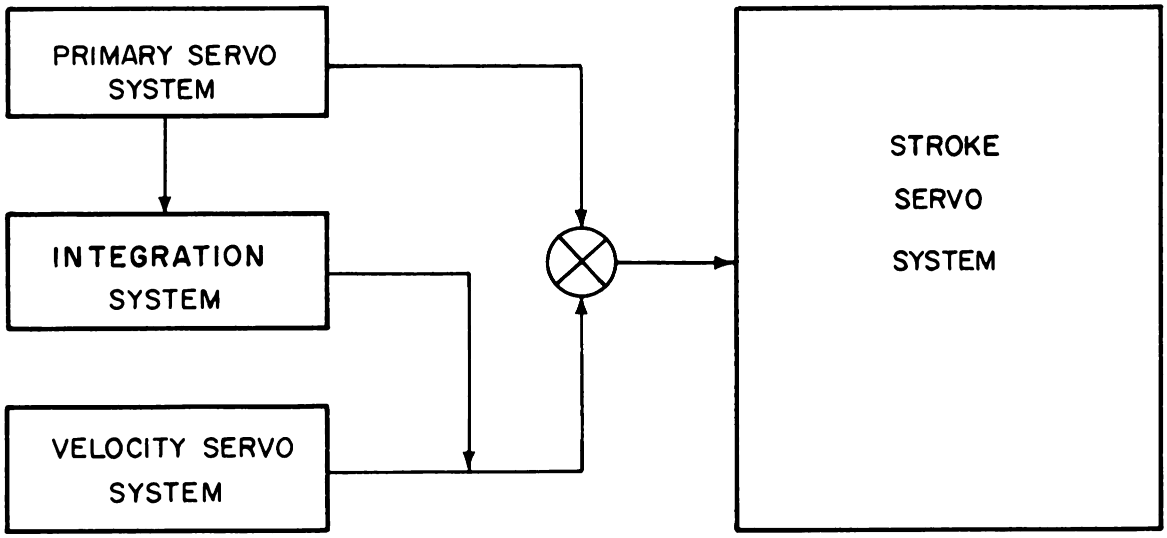
The primary servo system receives the remote order signal and supplies the position input to the power drive.

The velocity servo system receives from the remote control station a signal which is proportionate to the velocity order input. The purpose of this signal is to increase the speed and accuracy of the launcher as it synchronizes with the dynamic signals.

The integration system signal

originates within the regulator. The purpose of this signal is to improve launcher performance when the launcher is following the dynamic signals.

Illustration #14-3 shows a block diagram of the regulator servo systems. These systems will be explained in detail in Topics 3, 4, and 5 of this section.



14-3. SERVO SYSTEM, BLOCK DIAGRAM

QUIZ SHEET:

1. The receiver regulator receives an order signal from a remote control station.

   True ______ or False ______.

2. The 5"38 cal. power drive uses one of the following regulators:

   a. Voltage regulator.
   b. Receiver regulator.
   c. Indicator receiver regulator.
   d. B-end synchro unit.

3. List the four major units which constitute the power-drive servo loop.

   a. ____________________.
   b. ____________________.
   c. ____________________.
   d. ____________________.

4. The receiver regulator Mk 45 converts the electric error signal to a hydraulic signal.

   True ______ or False ______.

5. The A-end tilt-response to the receiver regulator is of the following nature:

   a. Electrical.
   b. Electronic.
   c. Hydraulic.
   d. Mechanical.

6. The B-end response to the receiver regulator positions one of the following:

   a. CTB stators.
   b. CTB rotors.
   c. CX stators.
   d. CX rotors.

TOPIC 2: LOCATION, GENERAL ARRANGEMENT, AND FUNCTIONS OF COMPONENTS

You Are Now Going To Learn:

1. The location, general arrangement, and functions of the receiver-regulator sections and their components.

You Will Acquire Skill In:

1. Identifying the receiver-regulator components.

Discussion Points For This Topic Are:

1. Location and functions of the receiver-regulator sections.
2. Main valve-block.
3. Rotary-piston assembly.
4. Synchros and the associated gearing assembly.
5. B-end response gearing.
6. Limit-stop assembly.
7. Nonpointing zone valve-block.
8. A-end response assembly.
9. Review and summary.

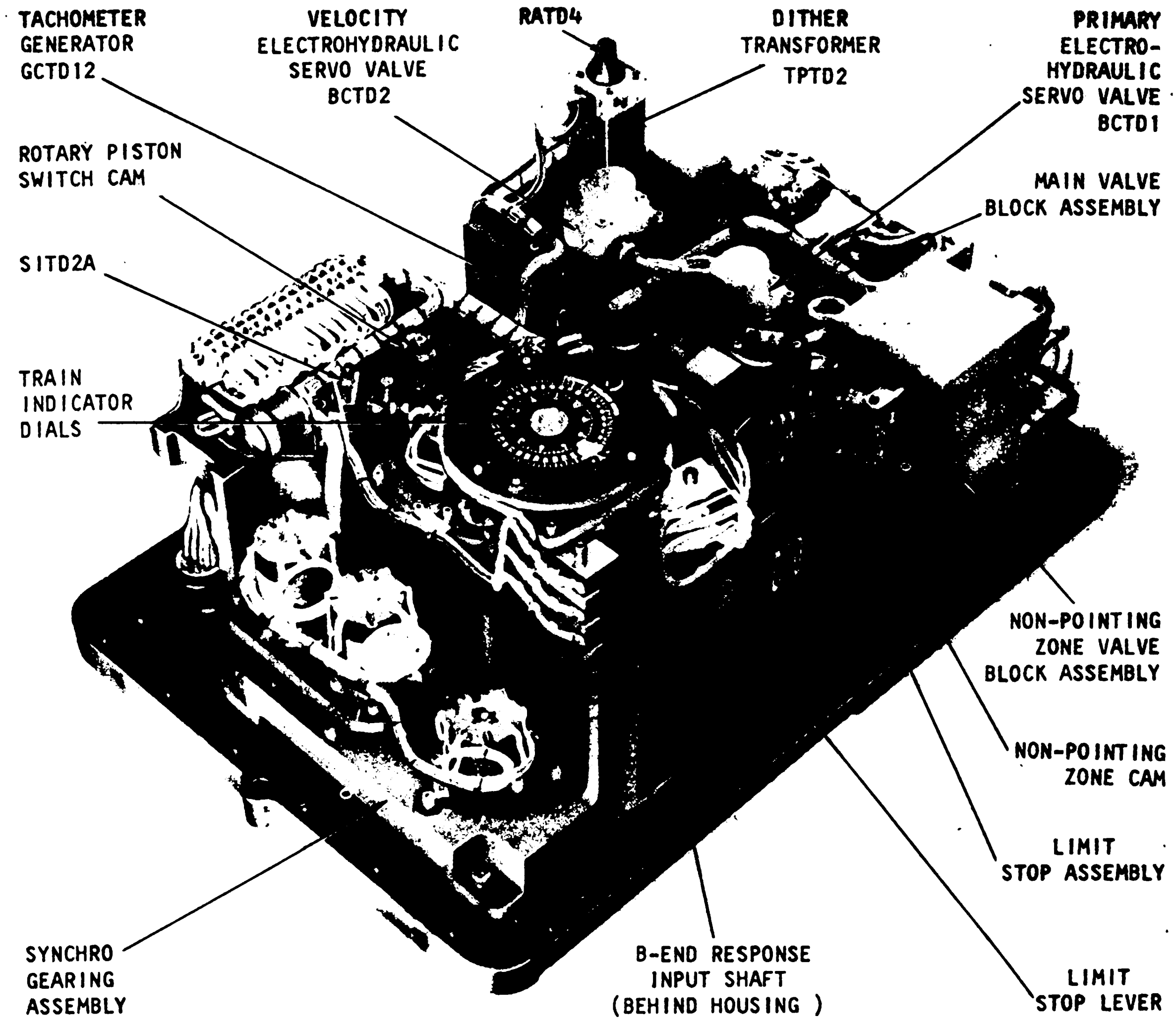
INFORMATION AND DISCUSSION:

The receiver regulator contains a multitude of components; therefore it is divided into sections to simplify component location and identification. The sections are designated as follows:

1. Main valve-block (including the control levers and the electrohydraulic servo valve).
2. Rotary-piston assembly.
3. Synchro gearing assembly.
4. B-end response gearing.
5. Limit-stop assembly.
6. Nonpointing zone valve-block.
7. A-end response assembly.

The main valve-block is located in the upper right-hand corner. (Refer to illustration #14-4 on the following page.) Mounted on top of the valve block is the dither transformer TPTD2 and its adjustment RATD4. The stroke-control and integration actuating levers (not shown in illustration #14-4) are located on the right-hand end of the valve block.

The rotary piston is located below the rotary-piston switch-cam, near the upper center part of the regulator. (Refer to illustration #14-4.)


TACHOMETER GENERATOR GCTD12
VELOCITY ELECTROHYDRAULIC SERVO VALVE BCTD2
RATD4
DITHER TRANSFORMER TPTD2
PRIMARY ELECTRO-HYDRAULIC SERVO VALVE BCTD1
ROTARY PISTON SWITCH CAM
MAIN VALVE BLOCK ASSEMBLY
SITD2A
TRAIN INDICATOR DIALS
NON-POINTING ZONE VALVE BLOCK ASSEMBLY
NON-POINTING ZONE CAM
LIMIT STOP ASSEMBLY
SYNCHRO GEARING ASSEMBLY
B-END RESPONSE INPUT SHAFT (BEHIND HOUSING)
LIMIT STOP LEVER

14-4. TRAIN RECEIVER REGULATOR

The synchro gearing assembly is located in the lower left-hand section of the regulator. This section includes the synchros, indicator dials, and position (response) switch-cams. (Refer to illustration #14-4.)

The B-end response input shaft extends through an opening in the regulator base-plate, near the lower center section of the regulator. (The approximate location of the shaft is shown in illustration #14-4.)

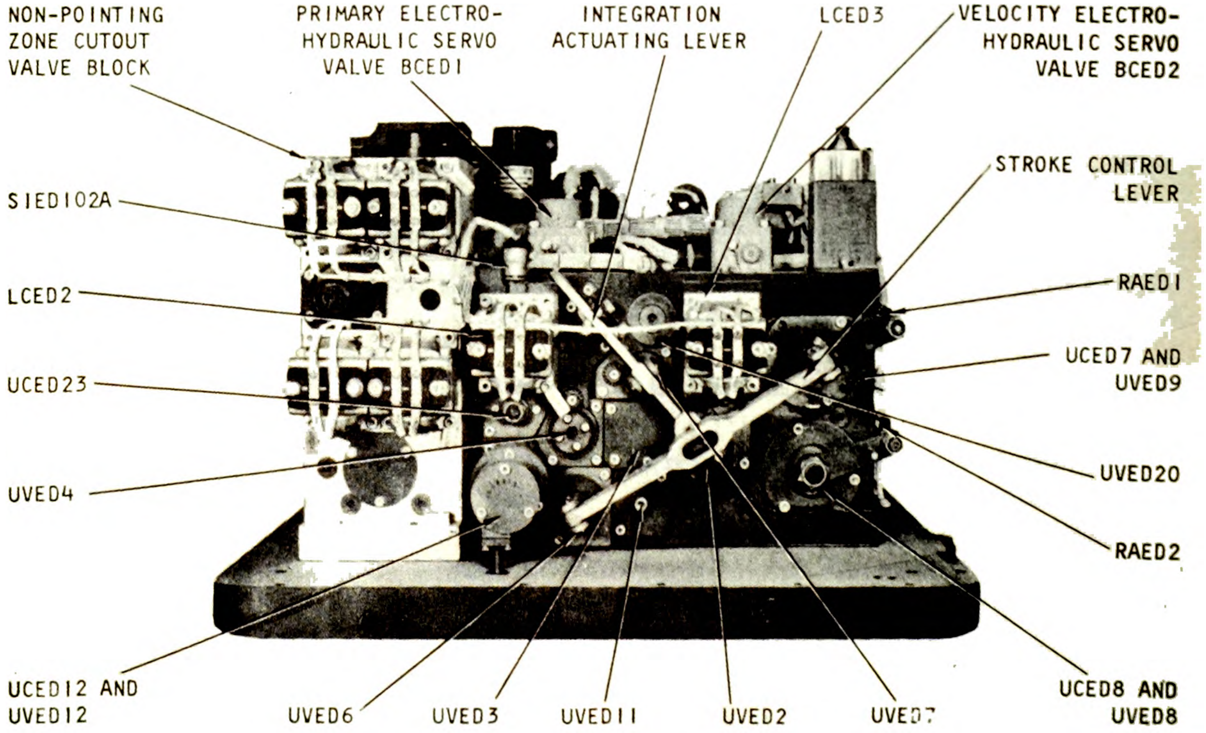
The limit-stop assembly is also located near the lower center section of the regulator and includes the position-plus-lead switch-cams and nonpointing zone cam. (Refer to illustration #14-4.)

The nonpointing zone valve-block assembly is located in the lower right-hand corner of the regulator. (Refer to illustration #14-4.)

The A-end response assembly shaft leads through an opening in the regulator base-plate. The opening is approximately in the center of the regulator, inboard of the limit-stop assembly. (The A-end response assembly cannot be seen in illustration #14-4.)

The main valve-block includes the components which are utilized by the primary, velocity, integration, and stroke servo systems. A description of the main valve-block components and their purposes will be given in the following text. The components can be seen in illustration #14-5 unless otherwise specified.

NOTE: Illustration #14-5 shows the components of the elevation receiver regulator. Since the locations of the components of the train and the elevation receiver regulators are identical, to find the location of the train components, you have to change only the third letter of the component designation from "E" to "T". For example, to find the


NON-POINTING ZONE CUTOUT VALVE BLOCK
PRIMARY ELECTRO-HYDRAULIC SERVO VALVE BCED1
INTEGRATION ACTUATING LEVER
LCED3
VELOCITY ELECTRO-HYDRAULIC SERVO VALVE BCED2
SIED102A
STROKE CONTROL LEVER
LCED2
RAED1
UCED23
UCED7 AND UVED9
UVED4
UVED20
RAED2
UCED12 AND UVED12
UVED6
UVED3
UVED11
UVED2
UVED7
UCED8 AND UVED8

14-5. ELEVATION RECEIVER REGULATOR

location of BCTD1, just change the designation BCED1 to BCTD1.

The components of the main valve-block and their functions are as follows:

BCTD1, the primary electro-hydraulic servo (moog) valve, converts the amplified primary electrical error signal to a hydraulic signal.

BCTD2, the velocity electro-hydraulic servo valve, converts the amplified electrical velocity and integration signal to a hydraulic signal.

UVTD14, the train rotary-piston neutralizing valve, is solenoid-operated and causes the rotary-piston to be returned to neutral, thereby neutralizing the primary system when the solenoid is de-energized. UVTD14 is located behind LCTD2.

UVTD3, the train pressure-regulator and integration-cutout valve, regulates the response pressure supplied to the rotary piston and causes the integration system to neutralize if the rotary-piston acceleration exceeds a predetermined value.

UVTD2, the train rotary-piston neutralizing and integration-cutout valve, transmits the primary error signal to the stroke servo-system. It can cause the integration system to be neutralized and originates the hydraulic signal to neutralize the rotary piston.

UVTD6, the stroke control servo valve, hydraulically controls the A-end stroke-pistons during normal operations.

UVTD11, the train acceleration-limit valve, limits the acceleration speed of the power drive.

UVTD10, the train velocity and integration-cutout valve, is solenoid-operated and causes the neutralization of the velocity and integration systems when LCTD3 is deenergized. UVTD10 is located behind LCTD3.

UCTD7, the train velocity piston, transmits the velocity and integration signal(s) to the stroke servo-system.

UVTD9, the train velocity piston neutralizing valve, develops the hydraulic pressure to neutralize the velocity piston.

UVTD7, the train integration control valve, develops the hydraulic pressure to operate the integration piston during normal operation. UVTD7 is mechanically operated by UVTD2.

UVTD20, the train integration neutralizing valve, can be controlled either by UVTD2, UVTD3, or UVTD10, to cause the integration system to neutralize.

UCTD8, the train integration piston, develops the electrical integration signal.

UVTD8, the train integration-piston neutralizing valve, develops the hydraulic pressure to neutralize the integration piston.

UVTD12, the train limit-stop valve, hydraulically controls the A-end stroke-pistons during limit-stop operations.

UCTD23, the train launcher-synchronized indication piston, is controlled by UVTD4 and actuates a switch (SITD26A) when the launcher is synchronized.

UVTD4, the launcher-synchronized indication valve, is mechanically controlled by UVTD2 and hydraulically controls UCTD23.

LCTD2, the train primary neutralizing solenoid, controls the operation of UVTD14.

LCTD3, the train velocity and integration neutralizing solenoid, controls the operation of UVTD10.

SITD102A, a switch, is mechanically actuated by LCTD2.

RATD1, the train velocity potentiometer, is a linear potentiometer positioned by UCTD7. The voltage developed on this potentiometer is fed back to the velocity amplifier, to cancel the velocity and integration signal(s) when UCTD7 has moved the ordered distance.

RATD2, the integration potentiometer, controlled by UCTD8, develops the integration signal-voltage to be applied to the velocity amplifier.

SITD19A, a test switch, is located on the inboard side of UVTD20 and used to check the operation of the integration system.

SITD26A, the launcher-synchronized switch, actuated by UCTD23, indicates that the launcher is within 21 minutes of synchronization. (The location of this switch can be seen in illustration #14-6 on the following page.)

TPTD2, the dither transformer, applies an oscillating signal to the primary section of the regulator, to decrease the static frictions within the valve block.

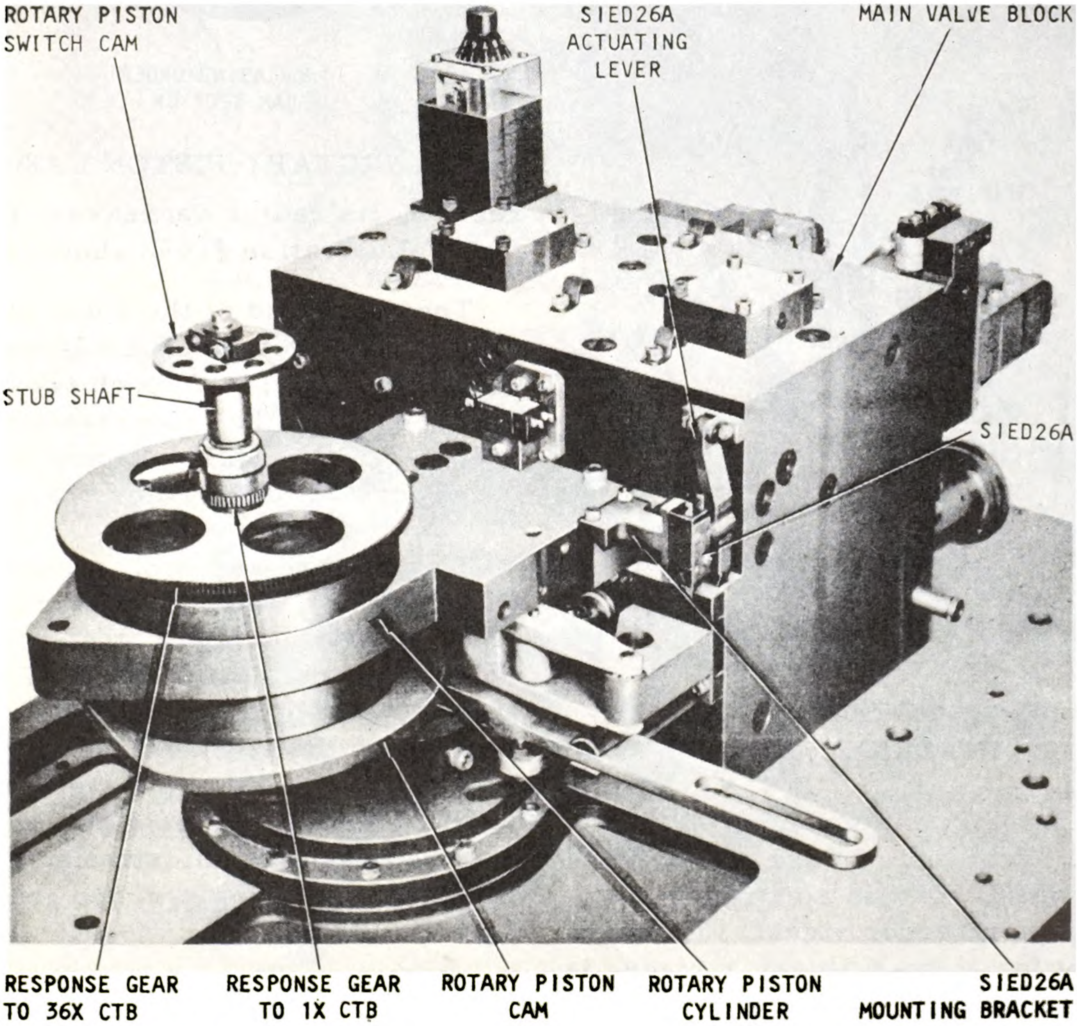
RATD4, the dither potentiometer, controls the amplitude of the dither input.

The train stroke-control lever spans from the upper right to the lower left corner of the valve block. Near its center, the lever is connected to UVTD2, to UCTD7 at its upper right end, and to UVTD6 at its lower left end. The stroke-control lever transmits the primary, velocity, and integration signals to the stroke servo system.

The train integration actuation lever spans from the upper left corner of the valve block to its center. The lever is connected to UVTD2 near the center of the valve block and to UVTD7 near the center of the lever. The upper end of the lever is adjustable and acts as a pivot point. The lever transmits the motion of UVTD2 to UVTD7, thereby controlling the integration signal.

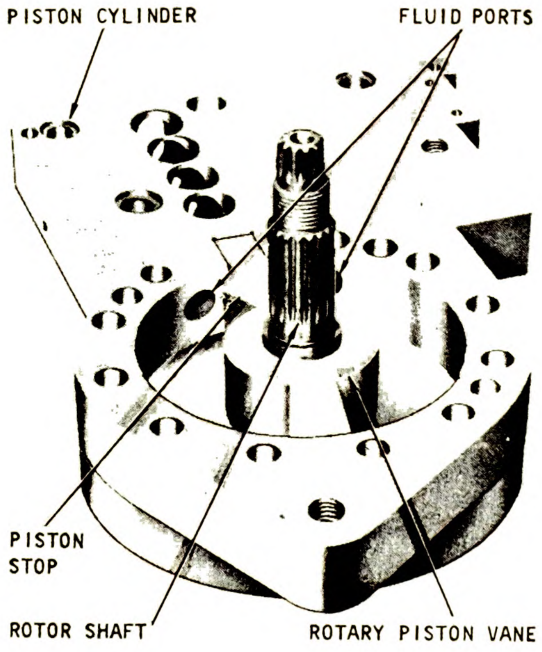
The train rotary-piston assembly, located inboard of the main valve-block, consists of a cylinder, piston vane, piston stop, piston cam, two response gears, and a switch cam with its associated switch. (Refer to illustration #14-6 below.)

The piston vane, located within the cylinder (refer to illustration #14-7 on the following page), is connected to a rotor shaft that extends through both ends of the cylinder. Two hydraulic fluid ports lead to the piston cylinder. The ports enter the cylinder on each side of the piston stop. The areas



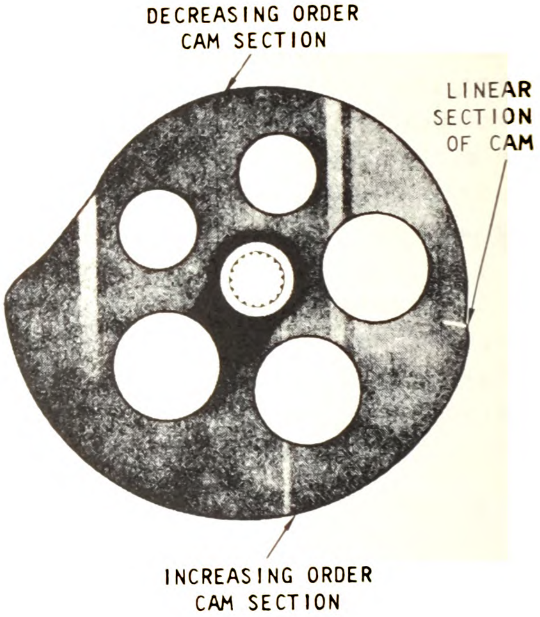
14-6. ROTARY PISTON ASSEMBLY

between the piston stop and each side of the piston vane form the hydraulic chambers. As long as the hydraulic pressure in each chamber remains equal, the rotary piston vane is stationary; however, if pressure in one chamber drops, the vane rotates in the direction of the lower pressure chamber. The vane movement is transmitted by the rotor shaft to the other regulator components.



14-7. ROTARY PISTON, INTERIOR VIEW

The rotary piston cam, splined to the lower end of the rotor shaft, positions UVTD2 in accordance with the primary error signal. The cam, except for a small linear surface, is cut so that if it is rotated in one direction, its radius increases, and if it is rotated in the opposite direction, its radius decreases. (Refer to illustration #14-8 above.)

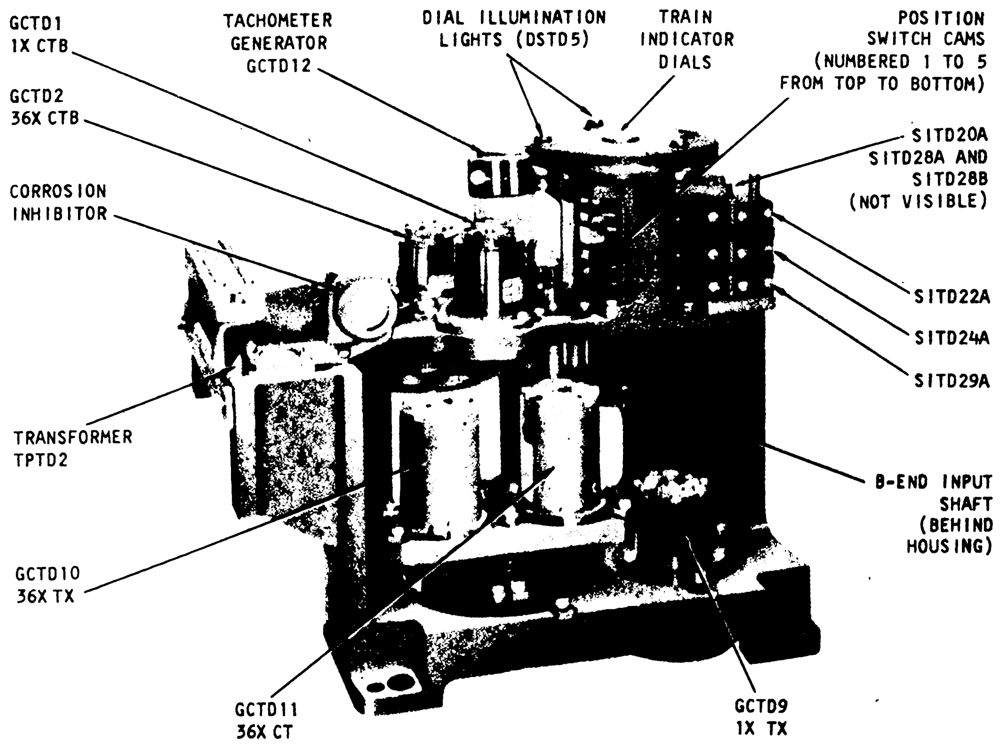


14-8. ROTARY PISTON CAM

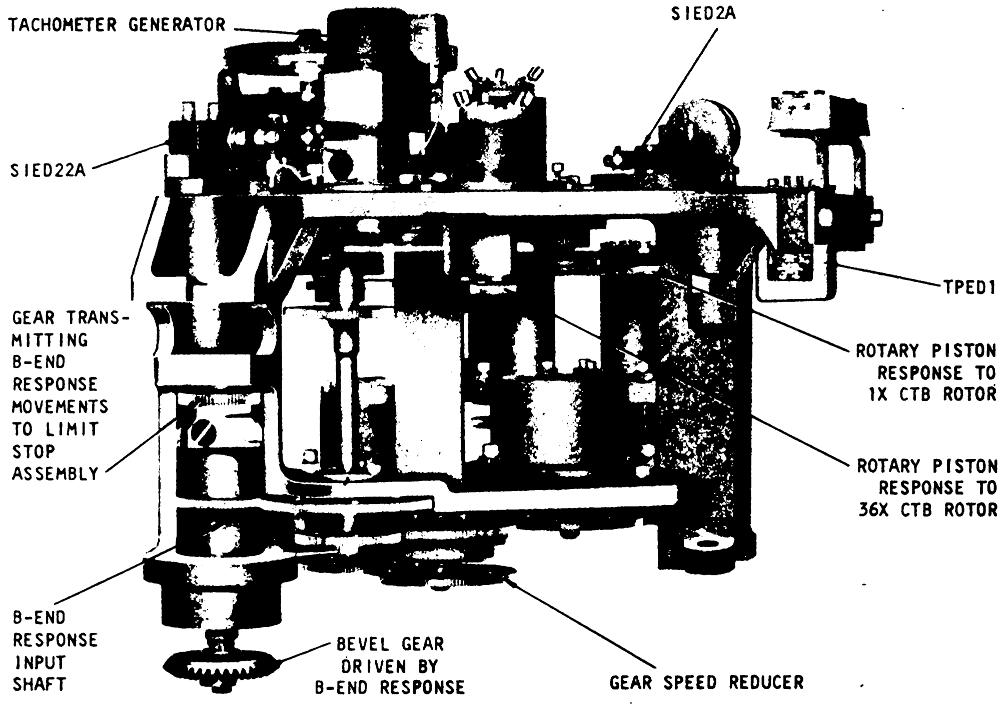
The upper end of the rotor shaft positions the rotors of the 1-speed and 36-speed CT's through two response gears. The rotary-piston switch-cam is also positioned by the upper end of the rotor shaft.

The synchro assembly mounts five synchros, the tachometer generator, indicator dials, the switches and their cams, transformer TPTD1, and the gearing from the B-end response and the stroke piston. (Illustration #14-9 shows the general arrangement of the train synchro gearing assembly; illustration #14-10 shows the elevation synchro gearing assembly.)

The synchros receive the order signal and transmit the launcher position to the control panels and



14-9. TRAIN SYNCHRO GEARING ASSEMBLY



14-10. ELEVATION SYNCHRO GEARING ASSEMBLY the fire-control system.

The tachometer generator transmits a launcher speed (velocity) signal for test purposes.

The indicator dial indicates launcher position and is driven by B-end response.

Transformer TPTD1 steps down the AC-voltage for dial illumination.

The switch cams (5 for train and 3 for elevation) are driven by B-end response and are used to actuate the switches which indicate the launcher train positions.

B-end response drives the stators of GCTD1 and GCTD2 and the rotors of GCTD9, GCTD10, and GCTD11.

Rotary piston response which is fed into the synchro assembly positions the rotors of GCTD1 and GCTD2. (The rotary-piston response and B-end response inputs fed into the synchro section are shown in illustration #14-10 on the preceding page.)

The B-end response input which is fed into the receiver regulator is led through the base plate and drives the bevel gear. (Refer to illustration #14-10.) The lower gear of the B-end response input shaft drives the synchro gearing, while the upper gear of this shaft drives the limit-stop assembly. (The B-end response is also often referred to as "position.")

The train limit-stop system includes the limit-stop assembly, the nonpointing zone valve-block, UVTD12, and part of the A-end response assembly. This system acts as a safety device to stop launcher movement whenever this is required for safe or proper operation.

The train limit-stop assembly (refer to illustration #14-11 on the following page) consists of a differential, a limit-stop brake, a nonpointing zone cam, and four switch cams.

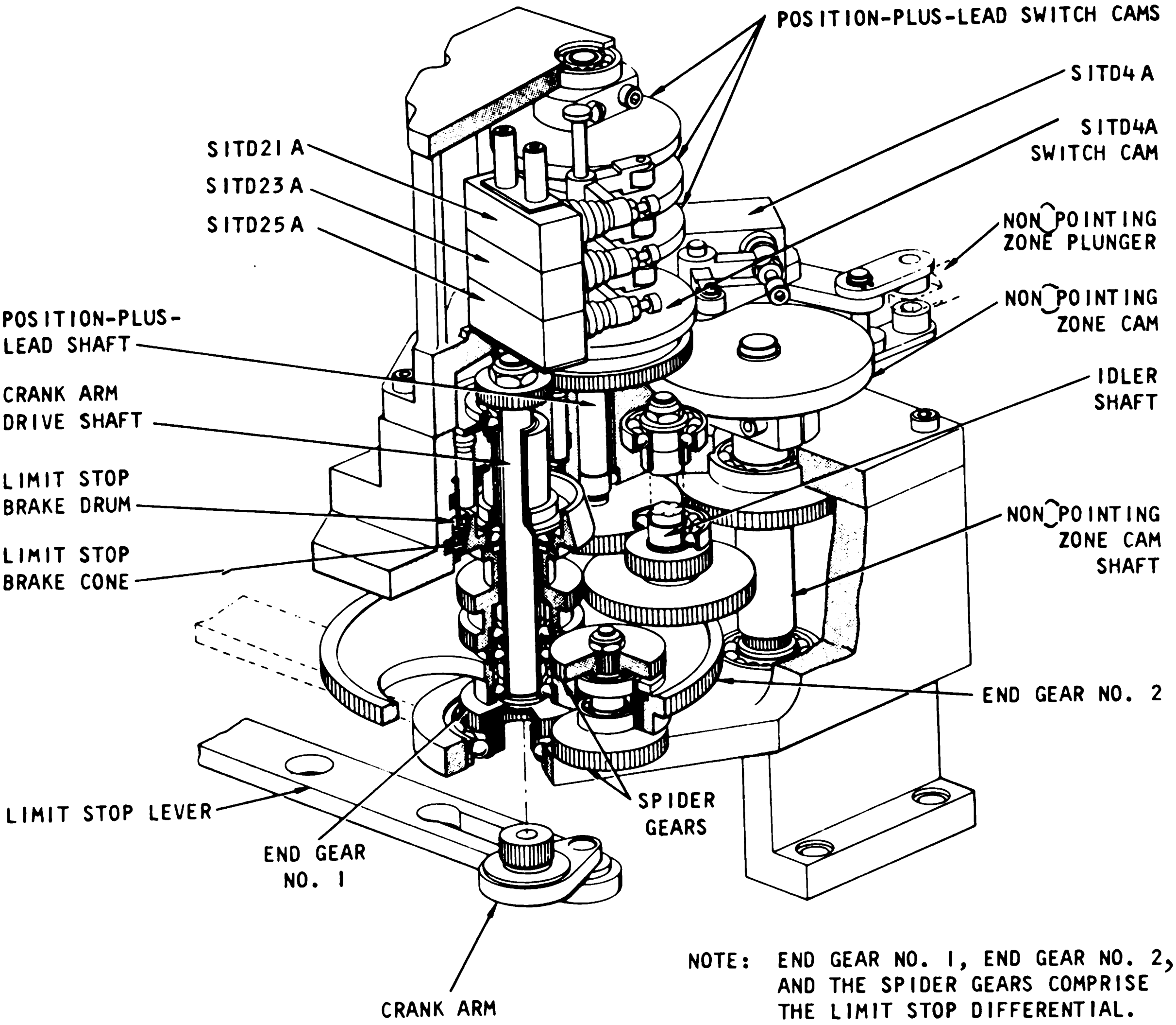
The differential constantly measures the launcher position (B-end response) and velocity (A-end tilt or lead) signals and feeds the result to the position-plus-lead cams and to the nonpointing zone cam.

Whenever a stop order is initiated by the limit-stop brake or by the nonpointing zone cam, the differential stops the launcher by positioning the crank arm.

During normal operation, B-end response is applied to the differential at end-gear #2; A-end response is applied at end gear #1. However, during limit-stop operation, end gear #1 acts as the output to stop the launcher.

The spider gears drive the position-plus-lead switch-cams and the nonpointing zone cam.

The elevation limit-stop assembly is similar to the train limit-stop assembly, except that instead of the



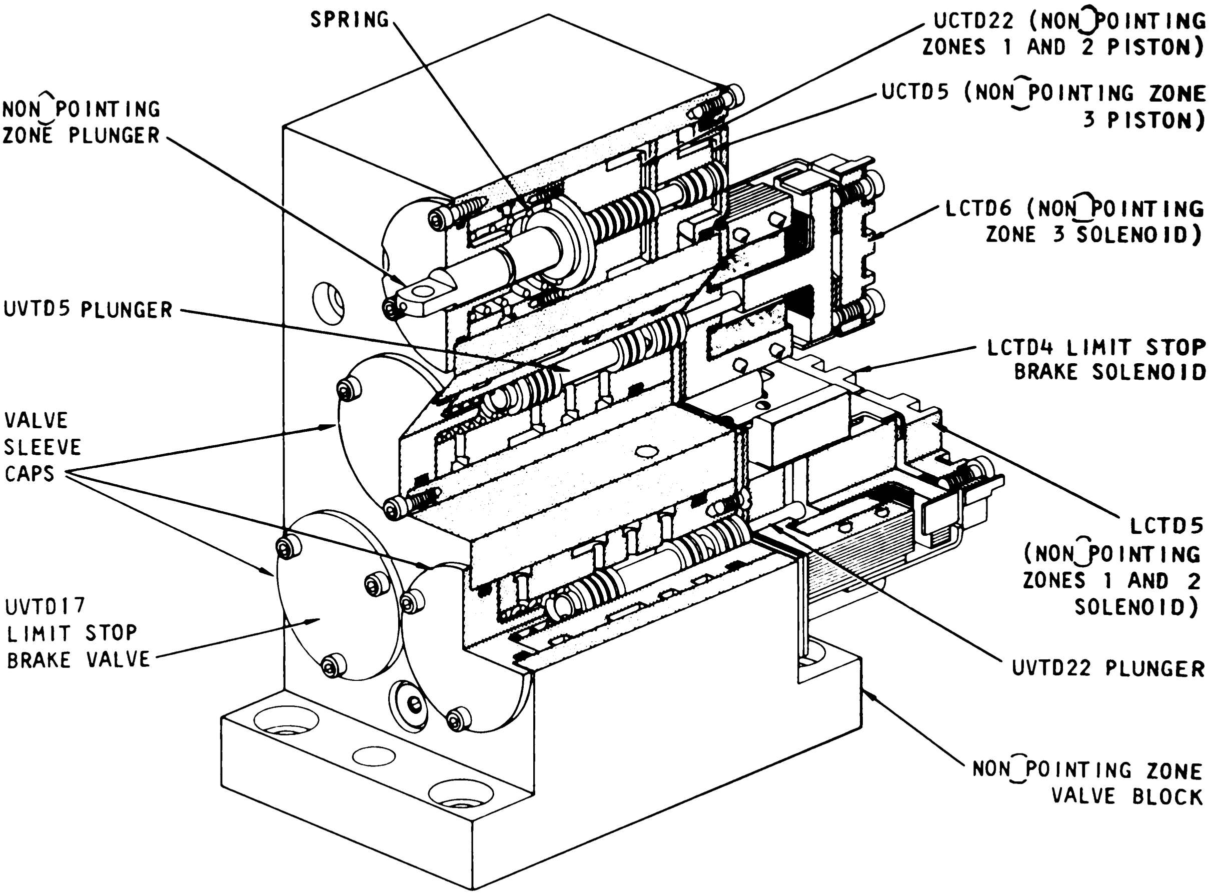
NOTE: END GEAR NO. 1, END GEAR NO. 2, AND THE SPIDER GEARS COMPRISE THE LIMIT STOP DIFFERENTIAL.

14-11. TRAIN LIMIT STOP SYSTEM

nonpointing zone cam, the elevation limit-stop assembly has a gear and rack which cause the elevation power drive to elevate the launcher guide arms over the nonpointing zones when the launcher guide arms are loaded.

The train nonpointing zone valve-block (refer to illustration #14-12 on the following page) consists of a limit-stop brake solenoid and valve, two nonpointing zone solenoids and valves, and two nonpointing zone pistons which, when extended, stop the nonpointing zone cam in the limit-stop assembly. Each piston is controlled by one of the nonpointing zone solenoid valves.

The elevation nonpointing zone valve-block differs from the train valve-block by the feature that the elevation block has three nonpoint-


SPRING
UCTD22 (NONPOINTING ZONES 1 AND 2 PISTON)
NONPOINTING ZONE PLUNGER
UCTD5 (NONPOINTING ZONE 3 PISTON)
LCTD6 (NONPOINTING ZONE 3 SOLENOID)
UVTD5 PLUNGER
LCTD4 LIMIT STOP BRAKE SOLENOID
VALVE SLEEVE CAPS
LCTD5 (NONPOINTING ZONES 1 AND 2 SOLENOID)
UVTD17 LIMIT STOP BRAKE VALVE
UVTD22 PLUNGER
NONPOINTING ZONE VALVE BLOCK

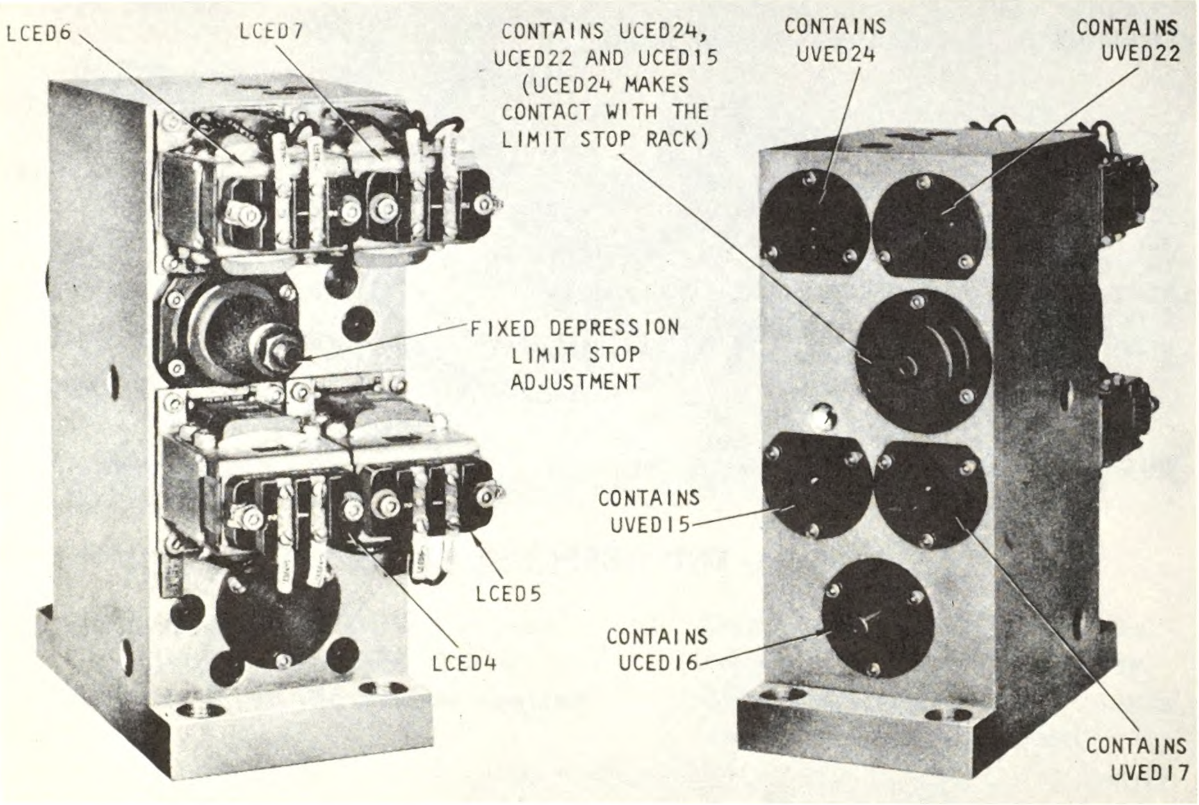
14-12. TRAIN NONPOINTING ZONE VALVE BLOCK ASSEMBLY

ing zone pistons and three nonpointing zone solenoid-operated valves.

The elevation nonpointing zone pistons act as the normal automatic depression stop for the elevation power drive; therefore a depression stop-adjustment has been added to this valve block. The elevation nonpointing zone pistons actuate a gear rack instead of a plunger as the train pistons do.

Another difference found on the first nine serial-numbered elevation regulators is the use of the hydraulically operated piston UCED16 in the elevation nonpointing zone valve-block. This piston prevents the stop cam on the elevation limit-stop assembly from turning 180° out of position during power operation. From serial #10 on, this cam was replaced by a crank arm similar to the crank arm used in the train limit-stop assembly.

In elevation receiver regulators serial #10 and above, UCED16 has been omitted. (Illustration #14-13 shows the elevation nonpointing zone valve block.)


LCED6
LCED7
CONTAINS UCED24, UCED22 AND UCED15 (UCED24 MAKES CONTACT WITH THE LIMIT STOP RACK)
CONTAINS UVED24
CONTAINS UVED22
FIXED DEPRESSION LIMIT STOP ADJUSTMENT
CONTAINS UVED15
LCED5
CONTAINS UCED16
LCED4
CONTAINS UVED17

FRONT VIEW

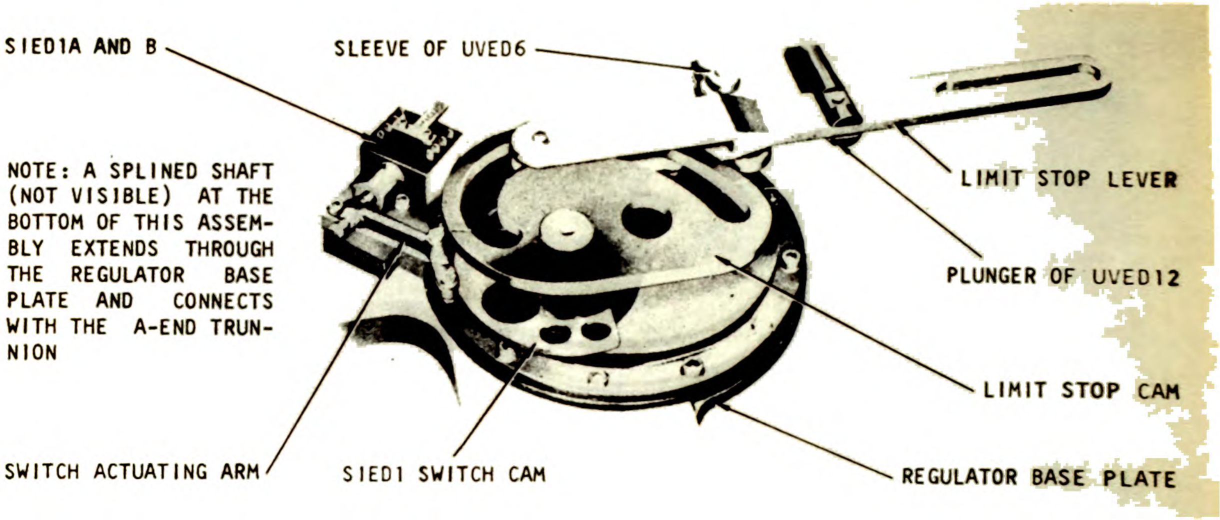
REAR VIEW

14-13. ELEVATION NONPOINTING ZONE VALVE BLOCK ASSEMBLY

The nonpointing zone components of the train and elevation receiver regulators prevent the launcher with loaded guided arms from training or elevating into any part of the ship's structure, by stopping the train power drive if necessary and by introducing an elevation order, thereby causing the launcher to clear the obstruction.

The A-end response assembly transmits the movement of the A-end tilt-plate, through a limit-stop cam and a lever, to the limit-stop assembly and UVTD12. A-end response also positions the sleeve of UVTD6 and a switch cam. (This A-end response is called "lead"; however on certain power drives it is often referred to as "tilt.")

NOTE: Illustration #14-14 shows the elevation (not train) A-end response assembly. The two assemblies, however, are physically and functionally alike.


SIED1A AND B
SLEEVE OF UVED6
NOTE: A SPLINED SHAFT (NOT VISIBLE) AT THE BOTTOM OF THIS ASSEMBLY EXTENDS THROUGH THE REGULATOR BASE PLATE AND CONNECTS WITH THE A-END TRUNNION
LIMIT STOP LEVER
PLUNGER OF UVED12
LIMIT STOP CAM
SWITCH ACTUATING ARM
SIED1 SWITCH CAM
REGULATOR BASE PLATE

14-14. A-END RESPONSE ASSEMBLY

QUIZ SHEET:

1. Transformer TPTD2 is located in one of the following:

   a. Nonpointing zone valve-block.
   b. Main valve-block.
   c. Limit-stop assembly.
   d. Rotary-piston assembly.

2. BCTD2 converts the primary electrical error signal to a hydraulic signal.

   True ______ or False ______.

3. Which of the following valves or pistons is not physically connected to the stroke control-lever?

   a. UVTD2.
   b. UVTD3.
   c. UVTD6.
   d. UVTD7.

4. The rotors of the 1-speed and 36-speed CTB's, GCTD1 and GCTD2, are positioned by the

   a. Rotary piston.
   b. B-end response.
   c. A-end response.
   d. Order signal.

5. Transformer TPTD1 supplies the voltage for dial illumination.

   True ______ or False ______.

6. The position-plus-lead cams are positioned by

   a. B-end response.
   b. A-end response.
   c. A- and B-end response.
   d. The rotary piston.

7. During limit-stop operation, which part of the limit-stop differential applies the output signal to stop the launcher?

   a. End gear #1.
   b. End gear #2.
   c. End gears #1 and #2.
   d. The spider.

8. The elevation nonpointing zone valve-block contains two nonpointing zone pistons and two nonpointing zone solenoid-operated valves.

   True ______ or False ______.

TOPIC 3: TRAIN POWER DRIVE CONTROL SYSTEM

You Are Now Going To Learn:

1. The functions of the receiver-regulator control system.

Discussion Points For This Topic Are:

1. Synchro system.
2. Amplifiers.
3. Primary servo loop.
4. Stroke servo loop.
5. Velocity servo loop.
6. Integration system.
7. Limit-stop and automatic tracking cutout system.
8. Neutralization.
9. Review and summary.

INFORMATION AND DISCUSSION:

A synchro system comprises the transmitting and receiving synchros necessary for the operation of a power drive. The receiver-regulator Mk 45 used in the launcher Mk 5 can be synchro-controlled in the following four modes of operation:

1. Remote--The remote order is used when the launcher is following a target. Remote orders originate in fire-control computers of the ship's weapon control system. Usually more than one remote order signal is available for launcher assignment.

2. Load--The load order automatically returns the launcher to the load position after the weapons have been fired. The synchros which originate load orders are usually fixed so that they always transmit the same order signal, unless the synchros are readjusted.

3. Local--The local order signal originates in manually operated CX's in the local control panel. Local control is normally used for moving the launcher during test, checkout, and maintenance.

4. Dud jettison-- The jettison orders originate in fixed synchros in a launching system control panel. There are two sets of synchros which transmit jettison orders, one set for each guide arm.

A 1-speed and **a 36-speed** CTB (GCTD1 and GCTD2) are utilized in the train receiver regulator. These CTB's act as receivers for the order signals. A CTB differs from a CT in that the CTB is bearing-mounted while a CT is not. This construction feature enables the CTB to receive mechanical response signals on the stator and on the rotor.

Illustration #14-15 shows the functional arrangement of the synchro system when the launcher is in remote mode of operation. The 400-cycle source-voltage is applied to the CX rotor windings, and the CX rotors are being positioned by the remote computer. The order signal generated by the CX's of the computer is transmitted via the stator windings to the 1-speed and 36-speed CTB's in the receiver regulator.

The CTB's in the receiver regulator receive the following inputs:

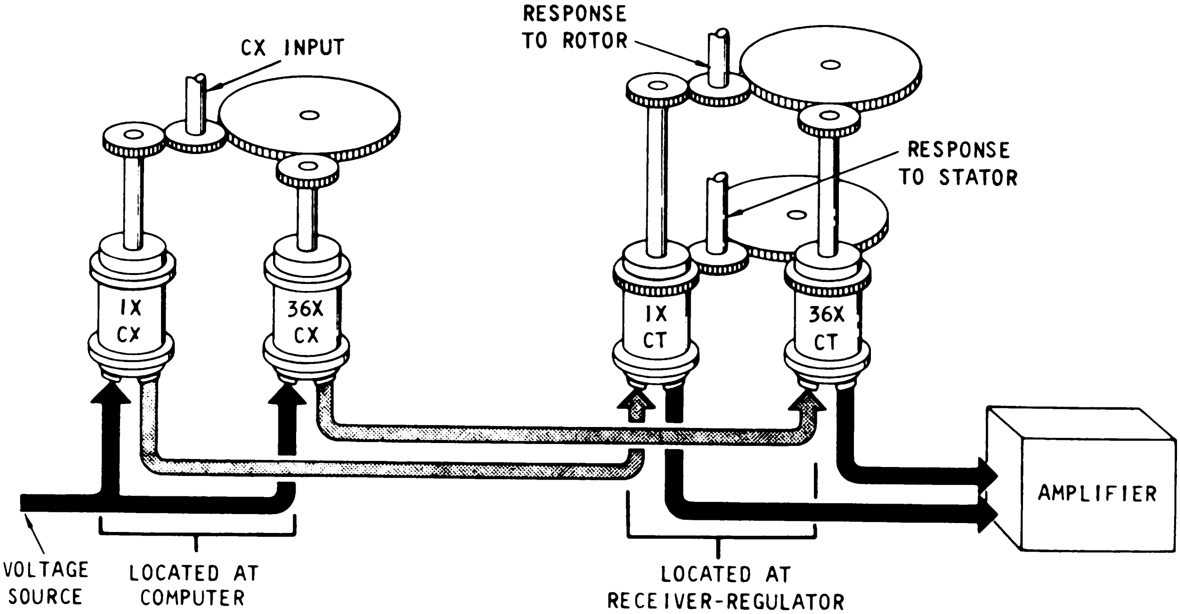
1. Order signals electrically applied to their stator windings.

2. B-end response mechanically applied to their stators.

3. Rotary piston response mechanically applied to their rotors.

By comparing the order signal to the two mechanical inputs, the CTB's generate electrical error signals on their rotor windings. The error signals are transmitted to the primary amplifier where either the 1-speed or the 36-speed error signal is selected for amplification. After the error signal is amplified, it is transmitted back to the receiver regulator where it is used to control an electrohydraulic servo valve, BCTD1 .

NOTE: When the error between the order position and launcher position is less than 4.8 degrees, the 36-speed signal is selected by the amplifier to control the

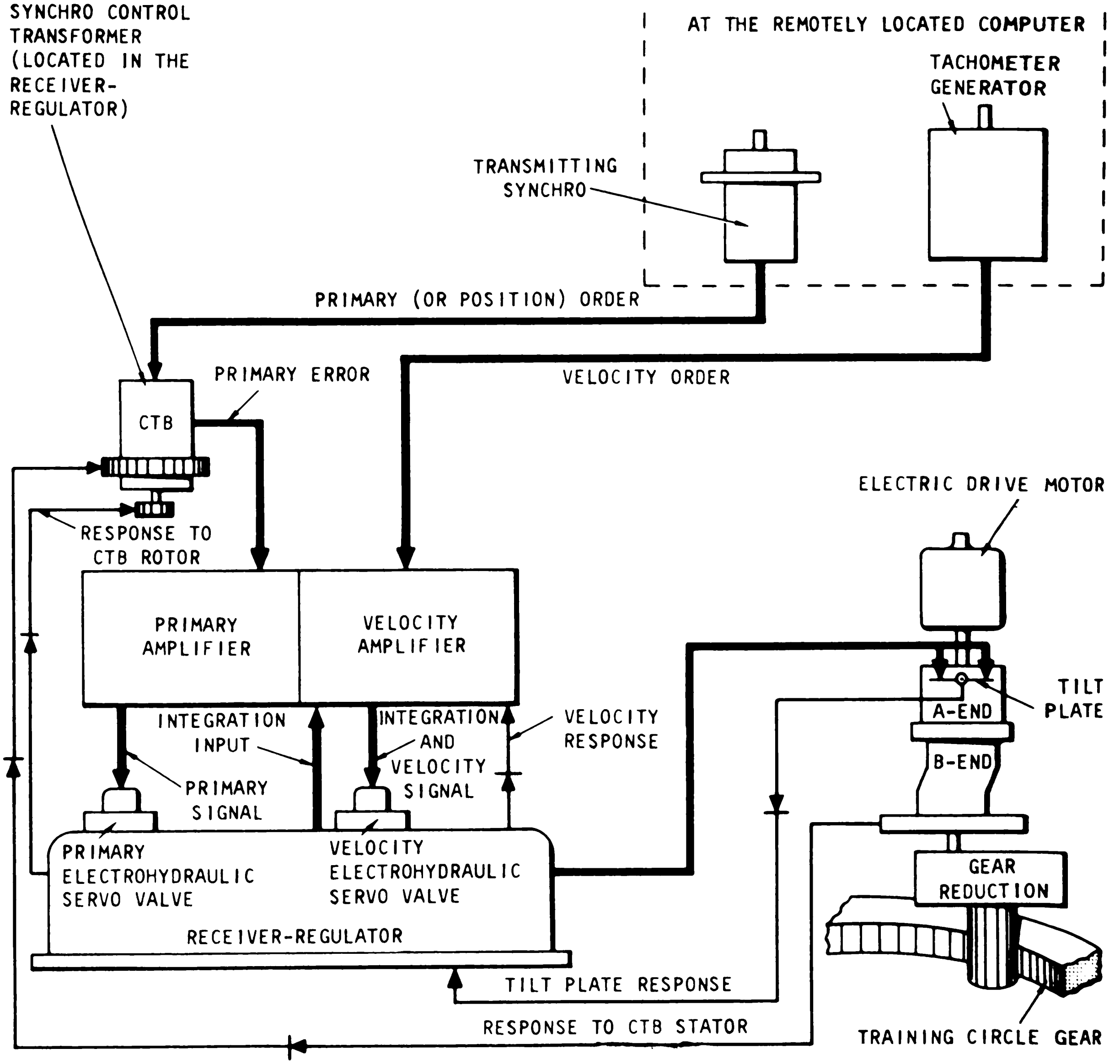


14-15. FUNCTIONS OF THE 1-SPEED AND 36-SPEED SYNCHROS launcher; when the error is more than 4.8 degrees, the 1-speed error signal is selected to control the launcher.

The train power drive uses two magnetic amplifiers (primary and velocity) to amplify the primary, velocity, and integration order-signals for control of the electrohydraulic servo valves.

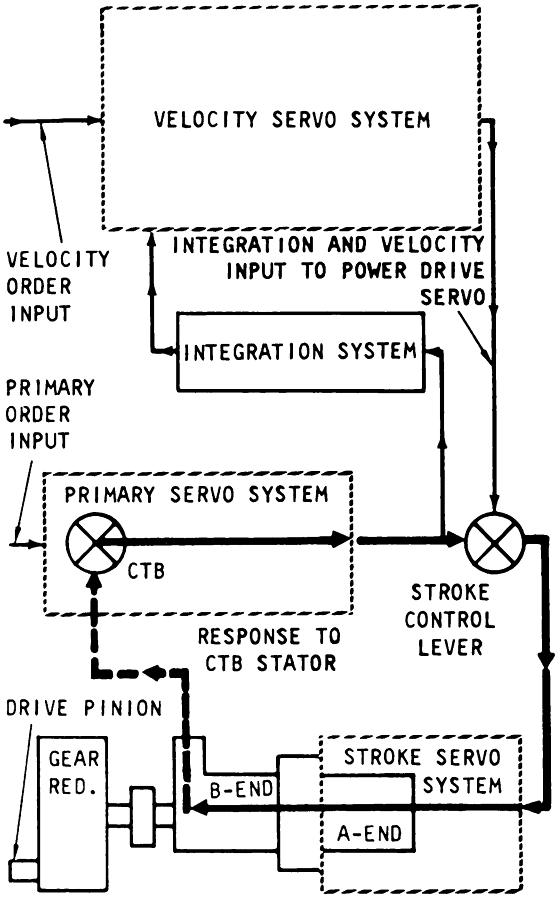
The train and the elevation power drive amplifiers are all four located in a common chassis in the launcher system control-panel.

The primary amplifier accepts the proper (1-speed or 36-speed) error signal, amplifies it, and transmits it to electrohydraulic servo valve BCTD1, while the velocity amplifier accepts both an



14-16. FUNCTIONS OF THE TRAIN CONTROL SYSTEM integration and a velocity order signal, amplifies these signals, and transmits a combined velocity-and-integration signal to electro-hydraulic servo valve BCTD2. (Illustration #14-16 on the preceding page is a functional diagram of the train control system. Note that only one transmitting synchro and one receiving synchro are shown to simplify the diagram.)

Illustration #14-17 below shows the servo loops used in normal operation of the launcher train power drive. Since the launcher control system is very complicated, the train system is presented as a multiple-loop servomechanism, to ease understanding of the functions of each loop.



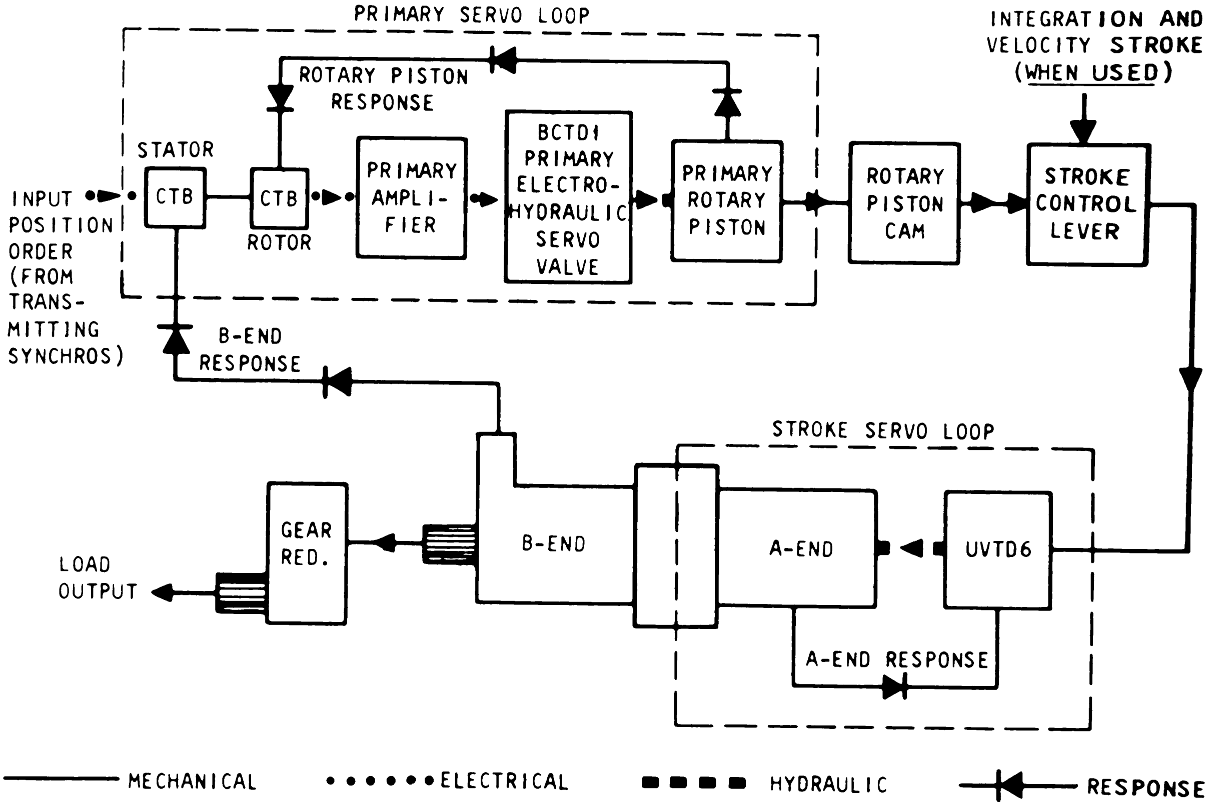
14-17. MULTIPLE LOOP SERVOMECHANISM

The power drive servo (traced by heavy arrows in illustration #14-17 and shown in detail in illustration #14-18 on the following page) can be considered the basic servo loop in the train system. Both the primary servo and stroke servo are located within the power-drive servo-loop.

Although the power drive servo is capable by itself of controlling launcher operations, certain additional systems are incorporated to perform related operations. These systems are:

1. The velocity servo system.
2. The integration system.
3. The limit-stop system.
4. The automatic tracking cut-out system.

The train primary servo loop (shown in illustration #14-18) consists of 1-speed and 36-speed CTB's, primary amplifier, valve BCTD1, and the rotary piston. Note that the feedback of the primary servo loop is transmitted from the rotary piston to the rotor of the CTB. When the launcher is operating in primary control with a constant dynamic



14-18. TRAIN POWER DRIVE SERVO SYSTEM

signal, this feedback cancels the error signal generated between rotor and stator of the CTB's.

When the primary servo error is zero, the rotary piston remains in its stroke-position until another order signal is applied to the CTB stator-field.

The rotary-piston cam UVTD2 and the stroke control-lever transmit the primary signal from the rotary piston to the stroke servo-system. UVTD2, UVTD3, and UVTD14, although they are part of the primary servo system, are not considered part of the primary servo loop. Note that the stroke control-lever acts as a differential or connecting link between the primary, velocity, and integration systems and the stroke servo-system.

The train-stroke servo loop (shown in illustration #14-18) comprises the A-end, plunger and sleeve of UVTD6, and stroke pistons.

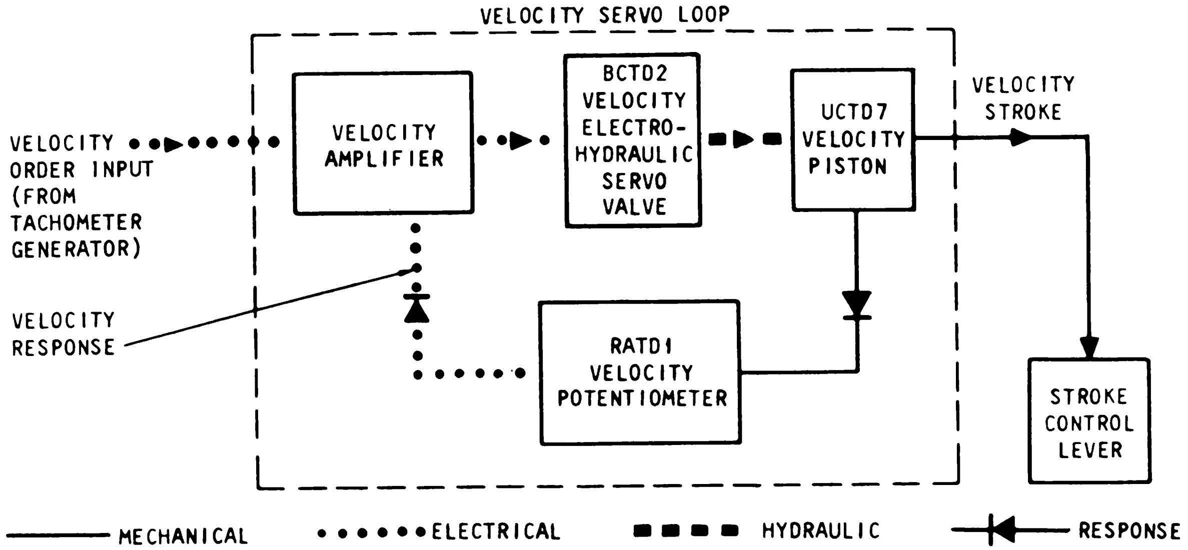
Whenever the stroke control-lever positions the plunger of UVTD6 in compliance with a primary, velocity, or integration signal, the plunger of UVTD6 causes the stroke pistons to move the A-end tilt-plate. The A-end tilt-response positions the sleeve of UVTD6 and thereby stops the movement of the stroke pistons, thus preventing further tilt-plate movements until another signal is applied to the plunger of UVTD6.

UVTD11 is part of the stroke servo system, but is not considered part of the stroke servo loop.

The train velocity servo system increases the speed and accuracy of the launcher when the launcher synchronizes to dynamic signals. The train velocity servo is a closed loop control system in regard to the velocity piston movements, but can be considered an open loop servo in regard to launcher movements, because there is no response fed back to the velocity servo which would indicate launcher movement.

The velocity servo loop (shown in illustration #14-19 below) consists of the velocity order input, velocity magnetic amplifier, electrohydraulic servo valve BCTD2, velocity piston UCTD7, and velocity potentiometer RATD1. The tachometer generators in the remote and local control stations produce the velocity order signal. This signal is proportional in voltage to the speed ordered by the controlling station and changes polarity with the direction ordered by the controlling station.

The tachometer signal is amplified and then used to control BCTD2 which converts the electrical velocity signal to a hydraulic signal and controls the movement of UCTD7. In turn, UCTD7 controls the movement of the stroke lever and, by positioning RATD1, develops the response signal which is fed back to the velocity amplifier. The feedback (response) signal cancels the velocity signal and stops UCTD7 when the velocity order has been carried out.



14-19. TRAIN VELOCITY SERVO SYSTEM

UVTD9 and UVTD10 are part of the velocity system, but are not considered part of the velocity servo loop.

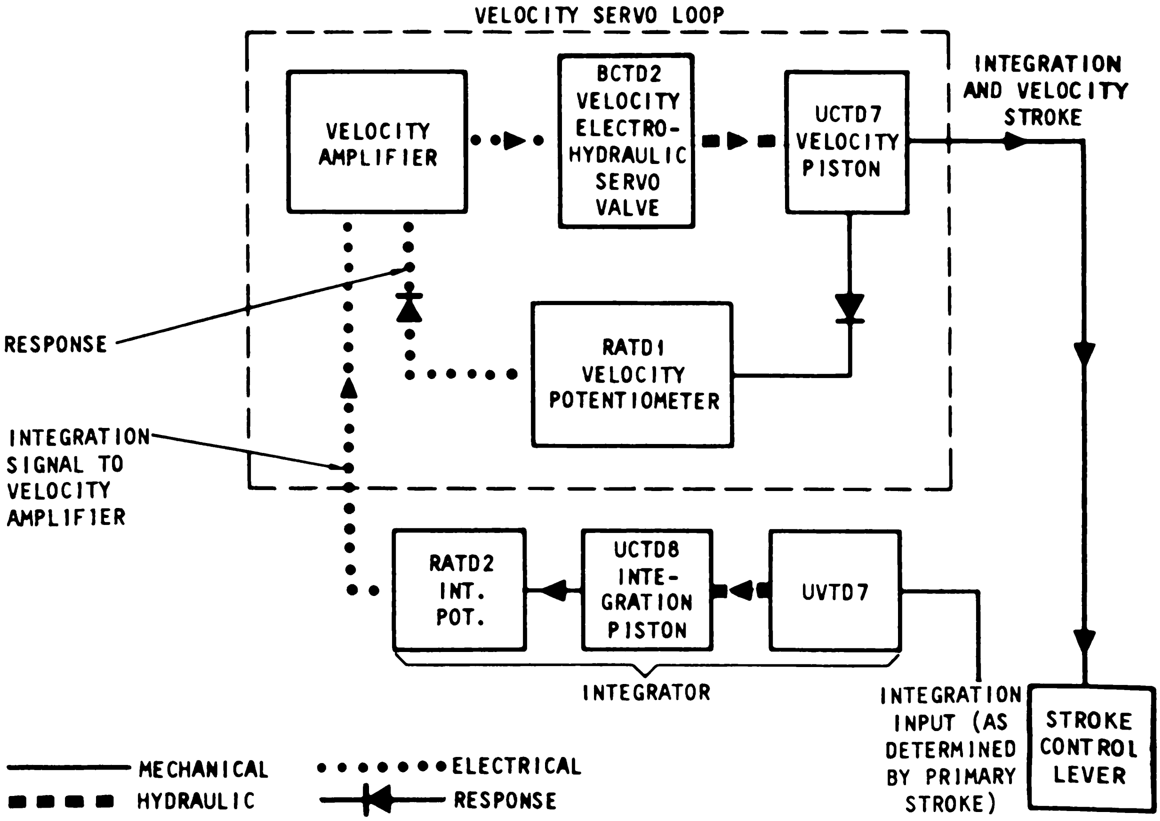
The train integration system improves launcher performance by reducing the error when the launcher follows a dynamic signal. Note that the integration signal is unique, since it is originated by the primary signal and uses the velocity system to apply its signal to the A-end.

Illustration #14-20 shows the integrator and how it uses the velocity servo loop as an output.

The integration system components which develop the integration signal are as follows:

1. Integration actuating lever.
2. Integration control valve UVTD7.
3. Integration piston UCTD8.
4. Integration potentiometer RATD2.

UVTD8 and UVTD20 are part of the integration system, but do not develop the signal.


VELOCITY SERVO LOOP
VELOCITY AMPLIFIER
BCTD2 VELOCITY ELECTRO-HYDRAULIC SERVO VALVE
UCTD7 VELOCITY PISTON
INTEGRATION AND VELOCITY STROKE
RESPONSE
RATD1 VELOCITY POTENTIOMETER
INTEGRATION SIGNAL TO VELOCITY AMPLIFIER
RATD2 INT. POT.
UCTD8 INTE-GRATION PISTON
UVTD7
INTEGRATOR
INTEGRATION INPUT (AS DETERMINED BY PRIMARY STROKE)
STROKE CONTROL LEVER
MECHANICAL
HYDRAULIC
ELECTRICAL
RESPONSE

14-20. INTEGRATION SYSTEM

Valves UVTD2, UVTD3, and UVTD10 are not considered part of the integration system, but they are capable of cutting the integration signal in or out of the train power drive.

The integration actuating lever imparts the movement (primary stroke) of UVTD2 to UVTD7. The magnitude of the integration stroke depends upon the magnitude of the primary stroke and the length of time that the primary stroke is applied.

UVTD7 hydraulically controls UCTD8, and UCTD8, by controlling the movement of RATD2, develops the electrical integration signal. This signal is fed to the velocity magnetic amplifier where it is combined with the velocity input signal and helps control the output of the velocity servo system.

The train and elevation power-drive limit-stop system and automatic tracking cutout system are similar in certain regards, since both are used to stop the launcher, if the situation warrants, and both employ the same method of bringing the A-end to neutral.

The train limit-stop system can stop the launcher by setting the limit-stop brake; however, this is done only when a power failure occurs.

The elevation power drive has fixed depression and elevation limit-stops plus a limit-stop brake. The train power drive has no fixed limit-stops.

The train and elevation automatic tracking cutout systems prevent a loaded launcher guide-arm from training or depressing into a nonpointing zone. This is achieved by causing the A-ends of the power drives to return to neutral.

The elevation power drive can also be signaled to elevate the launcher over a nonpointing zone when the launcher is training into a nonpointing zone with the guide arm depressed below the zone.

NOTE: A nonpointing zone is a certain area where a missile on a launcher guide-arm could be damaged by contacting the ship's structure, or could be fired from and hit the ship's superstructure.

The train and elevation regulator components utilized by both the limit-stop system and automatic cutout system to stop the power drives are listed below.

1. Limit-stop differential.
2. Limit-stop lever.
3. Limit-stop cam.
4. Limit-stop valve.

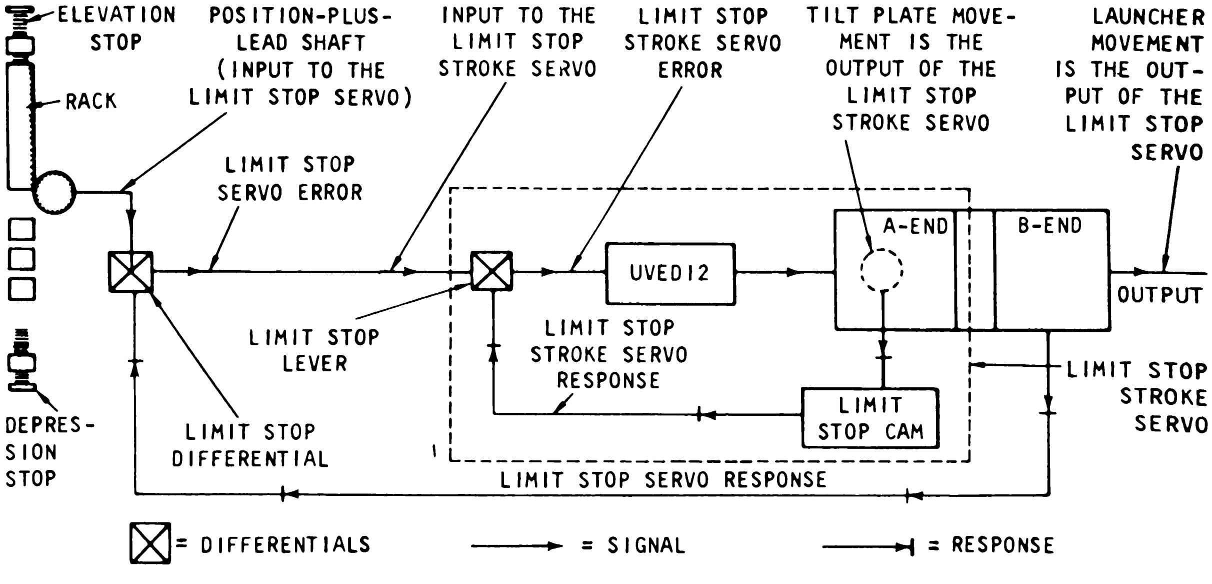
Both systems when they are not operating to stop the launcher are acting as linkages for transmitting indications of launcher position and launcher velocity (B-end response and A-end tilt) to the position-plus-lead shaft. When an order is received to stop or to elevate the launcher, the limit stop and automatic cutout systems each may act as a closed loop servo.

Illustration #14-21 below shows the elevation limit-stop causing the elevation power drive A-end to be returned to neutral.

The elevation brake (not shown in illustration #14-21) is located between the limit-stop differential and the gear that drives the rack. Because of the location of the brake, the limit-stop servo operation is the same for limit-stop and for limit-brake.

When the elevation power drive is being controlled by the automatic tracking cutout system, the depression limit is extended by hydraulically operated pistons. If a loaded guide arm is depressed into a nonpointing zone, the elevation power drive is stopped by the limit-stop servo. However, if a loaded guide arm is trained into a nonpointing zone, the pistons extend and cause the elevation power drive to elevate the launcher clear of the nonpointing zone.

The train limit-stop and automatic tracking cutout servo systems operate in the same way as the ones for elevation, except that in train there are no fixed positive stops and the nonpointing zone plungers extend


ELEVATION STOP
RACK
DEPRESSION STOP
POSITION-PLUS-LEAD SHAFT (INPUT TO THE LIMIT STOP SERVO)
LIMIT STOP SERVO ERROR
INPUT TO THE LIMIT STOP STROKE SERVO
LIMIT STOP STROKE SERVO ERROR
TILT PLATE MOVEMENT IS THE OUTPUT OF THE LIMIT STOP STROKE SERVO
LAUNCHER MOVEMENT IS THE OUTPUT OF THE LIMIT STOP SERVO
A-END
B-END
UVED12
OUTPUT
LIMIT STOP LEVER
LIMIT STOP STROKE SERVO RESPONSE
LIMIT STOP CAM
LIMIT STOP STROKE SERVO
LIMIT STOP DIFFERENTIAL
LIMIT STOP SERVO RESPONSE
= DIFFERENTIALS
= SIGNAL
= RESPONSE

14-21. LIMIT STOP COMPONENTS ACTING AS A SERVO (AFTER RECEIVING A STOP ORDER FROM THE POSITION-PLUS-LEAD SHAFT) to stop a cam located on the position-plus-lead shaft. Note that the train plungers do not stop the launcher unless the elevation power drive is unable to elevate the launcher fast enough to clear the nonpointing zone.

Neutralization is a method used by the receiver regulator to prevent a velocity or integration signal from being applied to the stroke servo-system, also a method used to cause the primary system, and thus the stroke servo system, to return to neutral (no A-end tilt). In other words, when a piston is neutralized, it is hydraulically returned to its neutral position, or to a position of no-output-signal.

QUIZ SHEET:

1. List the four modes of launcher operation.

   a. ____________________
   b. ____________________
   c. ____________________
   d. ____________________

2. A CTB is a bearing-mounted control transformer.

   True _______ or False _______.

3. The 1-speed error signal controls the primary section of the receiver regulator if the error between the launcher and tracking station exceeds

   a. 1.8°.
   b. 2.8°.
   c. 3.8°.
   d. 4.8°.

4. The only function of the velocity amplifier is to amplify the velocity signal.

   True _______ or False _______.

5. The power drive servo, which is capable of controlling launcher operation, consists of one of the following system combinations:

   a. Velocity and stroke servo systems.
   b. Primary and stroke servo systems.
   c. Integration and stroke servo systems.
   d. Limit stop and stroke servo systems.

6. In regard to launcher movements, the velocity servo system is considered an open loop.

   True _______ or False _______.

7. The velocity order signal is originated by one of the following components:

   a. Control synchro transmitter.
   b. Potentiometer.
   c. Tachometer generator.
   d. Torque synchro transmitter.

8. Integration electrical order signals to the velocity amplifiers are originated by one of the following devices:

   a. Tachometer generator,
   b. Torque synchro transmitter.
   c. Potentiometer.
   d. Control synchro transmitter.

9. The train limit-stop system stops the launcher by contacting the fixed limit stops.

   True _______ or False _______.

10. Both the limit-stop system and automatic cutout system act as servo loops when they are not operating to stop the launcher.

    True _______ or False _______.

TOPIC 4: PRIMARY AND STROKE SERVO SYSTEMS

You Are Now Going To Learn:

1. General information about the receiver-regulator hydraulic circuits.
2. The primary and stroke servo system operations.

Discussion Points For This Topic Are:

1. Hydraulic pressures used in the receiver regulator.
2. Operation of a pressure-dividing valve.
3. Primary electrohydraulic servo valve BCTD1.
4. Primary system neutralizing valve UVTD14.
5. Rotary piston UCTD1.
6. Rotary piston neutralizing valve UVTD2.
7. Pressure regulating and integration cutout valve UVTD3.
8. Servo valve UVTD6.
9. Acceleration limiting valve UVTD11.
10. Stroke pistons UCTD2 and UCTD3.
11. Cycle of operation.
12. Review and summary.

INFORMATION AND DISCUSSION:

The hydraulic pressure for the operation of the receiver regulator is supplied by a gear pump and is regulated by an auxiliary relief valve-block. The pump is located on the opposite end of the electric motor from the power drive A-end. The auxiliary relief valve-block is mounted to the base ring, near the receiver regulator.

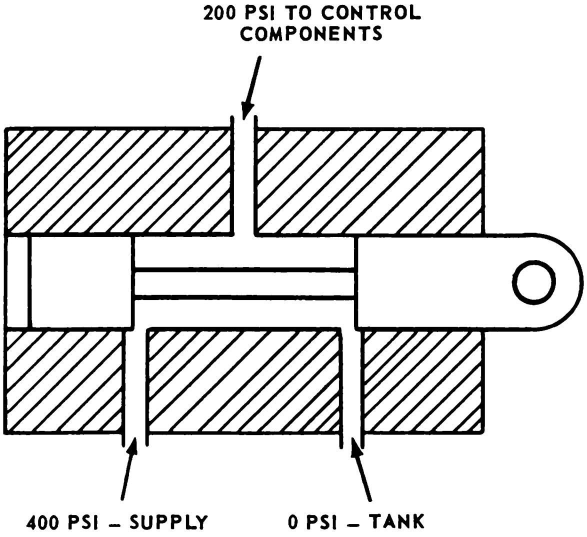
The pressure used to operate the receiver regulator is called servo pressure. It is maintained at 400 psi.

From the servo pressure in the receiver regulator, two other pressures are developed: One is the control pressure, which varies from 0 psi to 400 psi; the other is the regulated pressure, which is maintained at 200 psi. These two pressures are developed by special two-land pressure-dividing valves.

Illustration #14-22 on the following page shows an example of a simplified pressure-dividing valve. The valve is shown balanced (centered) in its neutral position, with each valve-land equally connected to a 400 psi and a 0 psi hydraulic port. When the valve is in this position (centered), the pressure in its chamber is maintained at 200 psi.

When the valve is moved from neutral to the left, equally opening the 400 psi port and equally closing the 0 psi port, the pressure in the chamber rises to above 200 psi; when the valve is moved from neutral to the right, equally closing the 400 psi port and opening the 0 psi port, the pressure in the valve chamber drops below 200 psi. The amount that the pressure in the valve chamber increases or decreases depends on the distance the valve is moved.

In order to simplify the explanation of the receiver-regulator operation, it will be assumed that the servo pressure is exactly 400 psi and the tank pressure 0 psi. (Actually, the servo pressure may be a little under or over 400 psi, and tank pressure is never exactly 0 psi. This assumption, however, will not affect the principles of receiver-regulator operation.)

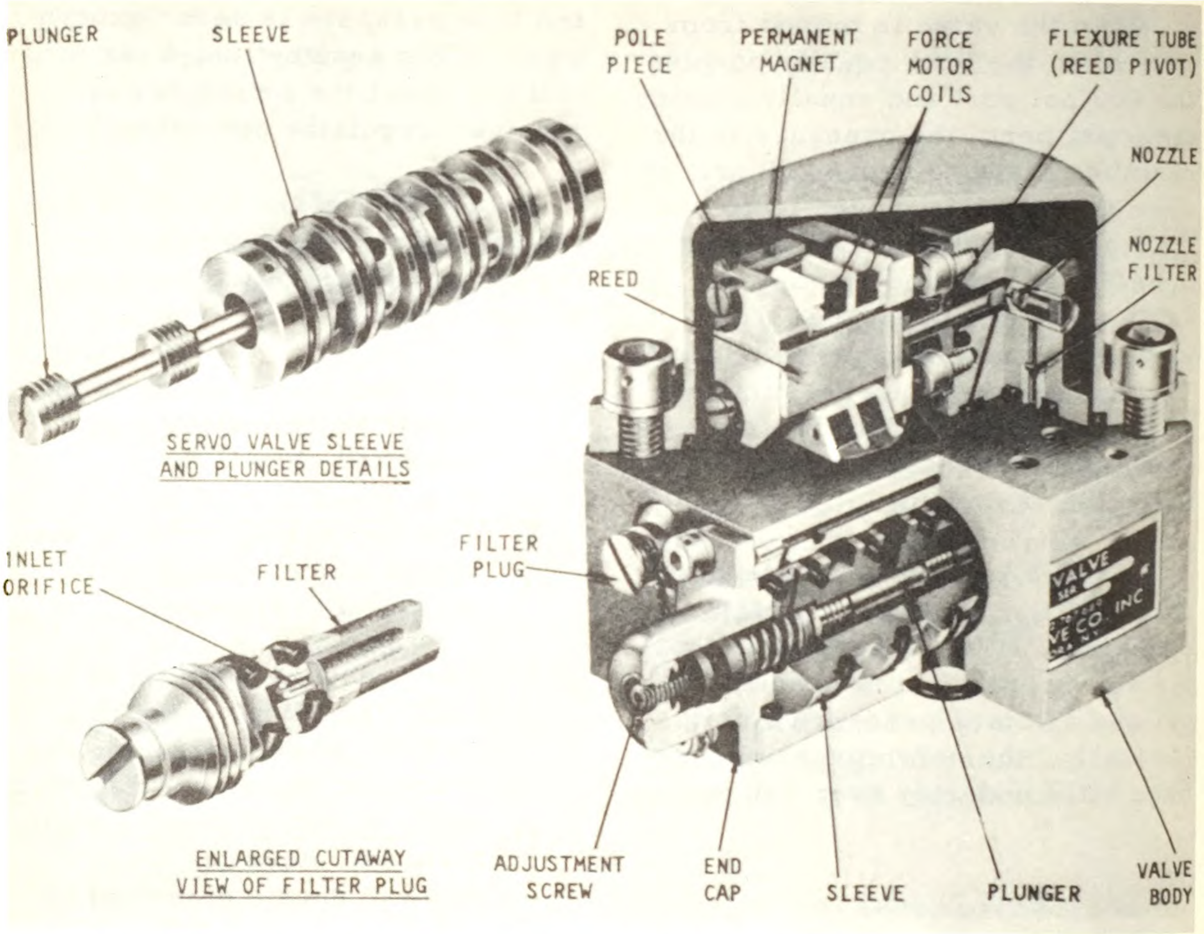


14-22. PRESSURE DIVIDING VALVE (SIMPLIFIED)

In the study of the theory of hydraulic operations in a receiver regulator, the following facts should be remembered:

1. The increasing order is the signal which causes right train and elevation.
2. The decreasing order is the signal which causes left train and depression.
3. The pressure-dividing valves (BCTD1, UVTD6, BCTD2, UVTD7) when developing the hydraulic signal to be applied to the A-end stroke for right train and elevation always move in such a direction as to port less than 200 psi from their center chambers.
4. The same pressure-dividing valves when developing the hydraulic signal to be applied to the A-end stroke for left train and depression always move in such a direction as to port more than 200 psi from their center chambers.

BCTD1, the electrohydraulic servo (moog) valve, converts the electric output of the train primary amplifier into a proportional hydraulic signal. BCTD1 consists basically of a force motor and a hydraulic amplifier.



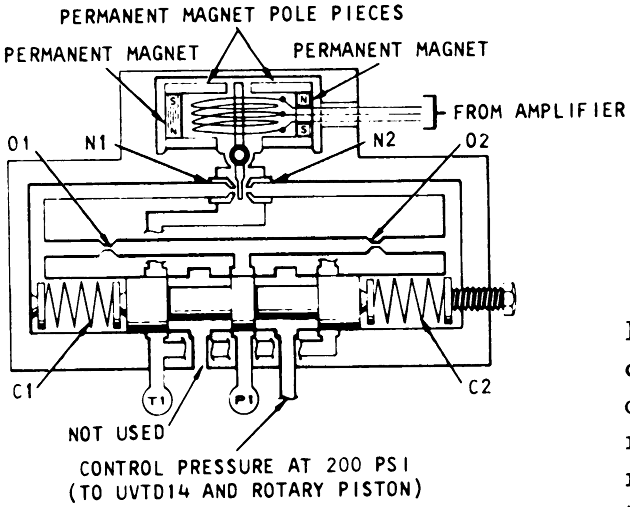
14-23. CUTAWAY VIEW OF ELECTROHYDRAULIC SERVO VALVE

The force motor transforms the amplifier input (a differential current) into a proportional movement of the motor reed. The motor consists of two permanent magnets, two pole pieces, two coils, and a reed. The permanent magnets hold the reed centered between the nozzles when the electric power is off. The two coils act as electromagnets to control the reed movements. When the amounts of current flowing through each coil are equal, the reed remains on neutral (centered between the pole pieces); however, if the current flowing through the coils becomes unbalanced, the reed moves away from its neutral position. (The reed is pivoted, with one end centered between the magnetic pole pieces and the other end centered between two hydraulic nozzles in the mixing chamber.)

The hydraulic amplifier converts the movement of the motor reed into control pressure capable of controlling the rotary piston. The amplifier consists of a mixing chamber, nozzles, orifices, and a spring-loaded servo-valve plunger. Movement of the reed causes a differential pressure on each end of the valve plunger. This unbalanced pressure upsets the balancing action of the two plunger springs and causes the plunger to move until the difference in hydraulic pressure has been balanced by spring action.

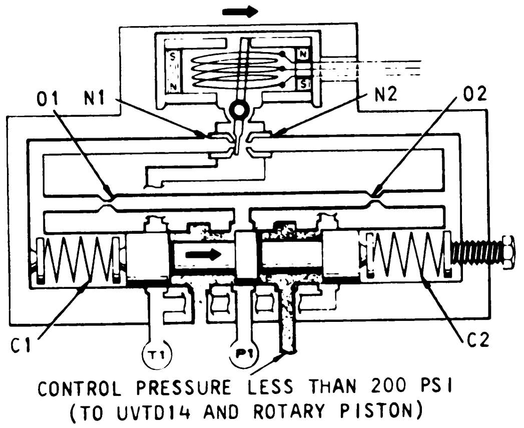
The plunger displacement is proportional to the differential electric input. The plunger displacement develops a corresponding output of control pressure. (Note in illustration #14-24 below that the left chamber of the servo valve is not used; actually, the chamber center-port is plugged.)

Illustration #14-24 shows servo pressure (P1) at 400 psi ported to and around the center land of the servo-valve plunger. From the center land, the servo pressure line branches to the two fixed orifices O1 and O2, to pressure chambers C1 and C2, and to nozzles N1 and N2. The reed controls the amount of fluid flow from each nozzle into the mixing chamber. From the mixing chamber, the pressure is ported to tank through T1.


PERMANENT MAGNET POLE PIECES
PERMANENT MAGNET
PERMANENT MAGNET
S
N
N
S
FROM AMPLIFIER
O1
N1
N2
O2
C1
C2
T1
P1
NOT USED
CONTROL PRESSURE AT 200 PSI
(TO UVTD14 AND ROTARY PISTON)

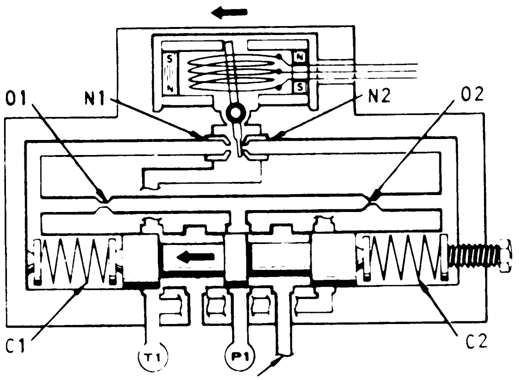
14-24. SERVO VALVE AT NEUTRAL

When the reed is balanced (refer to illustration #14-24), the amount of fluid flow through both nozzles is equal; consequently, the pressures in chambers C1 and C2 are equal. Thus, with the servo-valve plunger on neutral, the servo pressure (400 psi) and tank pressure (0 psi) are equally connected to the right chamber, and 200 psi control pressure is being developed for control of the rotary piston.


S
N
N
S
O1
N1
N2
O2
C1
C2
T1
P1
CONTROL PRESSURE LESS THAN 200 PSI
(TO UVTD14 AND ROTARY PISTON)

14-25. RIGHT TRAIN-STROKE

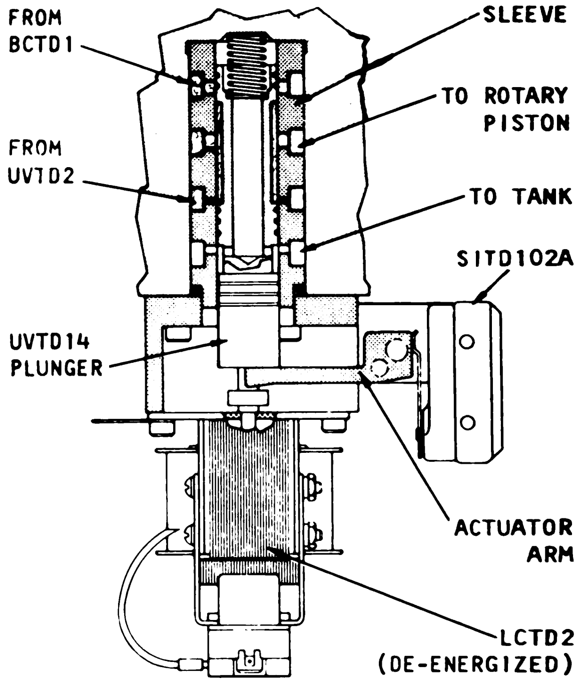
When a signal is applied to BCTD1 to tilt the A-end and to cause the launcher to train right or to elevate, the differential current to the force motor causes the reed to pivot as shown in illustration #14-25. The reed movement decreases the flow through nozzle N1 and increases the flow through nozzle N2, causing a differential pressure between chambers C1 and C2. Since the C1 pressure is higher, the servo valve plunger is displaced to the right, opening the tank port and closing the pressure port, thus causing the control pressure to become lower than 200 psi.



CONTROL PRESSURE GREATER THAN 200 PSI
(TO UVTD14.AND ROTARY PISTON)

14-26. LEFT TRAIN-STROKE

When a signal is applied to BCTD1 to remove the A-end tilt for right train and elevation or to apply tilt for left train and depression, the force-motor reed moves in the direction shown in illustration #14-26 above. The resulting pressure differential causes the valve plunger to move to the left. As a result, the control pressure from the plunger chamber becomes higher than 200 psi.

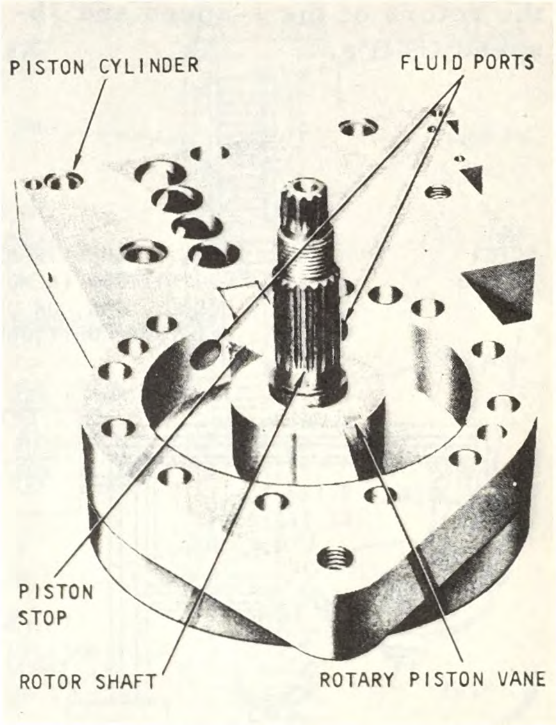


14-27. UVTD14 AND LCTD2

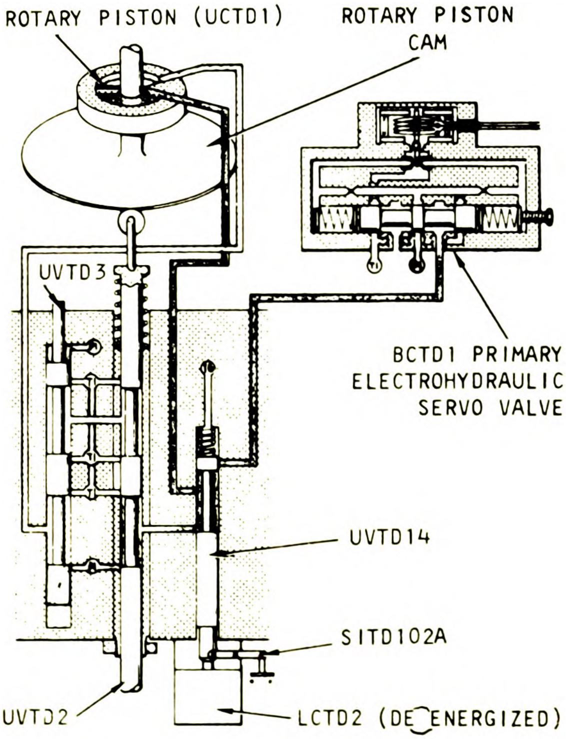
UVTD14, the primary-system neutralizing valve (refer to illustration #14-27), is operated by solenoid LCTD2. In normal operation, LCTD2 is energized, and the valve is moved against spring pressure away from the solenoid. When LCTD2 is energized, control pressure from BCTD1 is ported through the chamber of UVTD14, directly to the control chamber of the rotary piston UCTD1. When the launcher is being started or when a power failure occurs, LCTD2 is deenergized, allowing the spring to return the valve to the position shown in illustration #14-28 on the following page. The control pressure from BCTD1 is blocked by the upper land of UVTD14, and neutralizing pressure from UVTD2 is ported to the control chamber of UCTD1. The pressure from UVTD2 causes the rotary piston to return to neutral, thereby stopping the launcher. Switch SITD102A (shown in illustrations #14-27 and #14-28) opens the firing circuit whenever LCTD2 is deenergized.

UCTD1, the rotary piston, is enclosed by a cylinder. UCTD1 transmits the primary signal from BCTD1 to the rotary-piston cam and to the rotors of the 1-speed and 36-speed CTB's, thereby converting the primary hydraulic signal into a proportional mechanical signal.

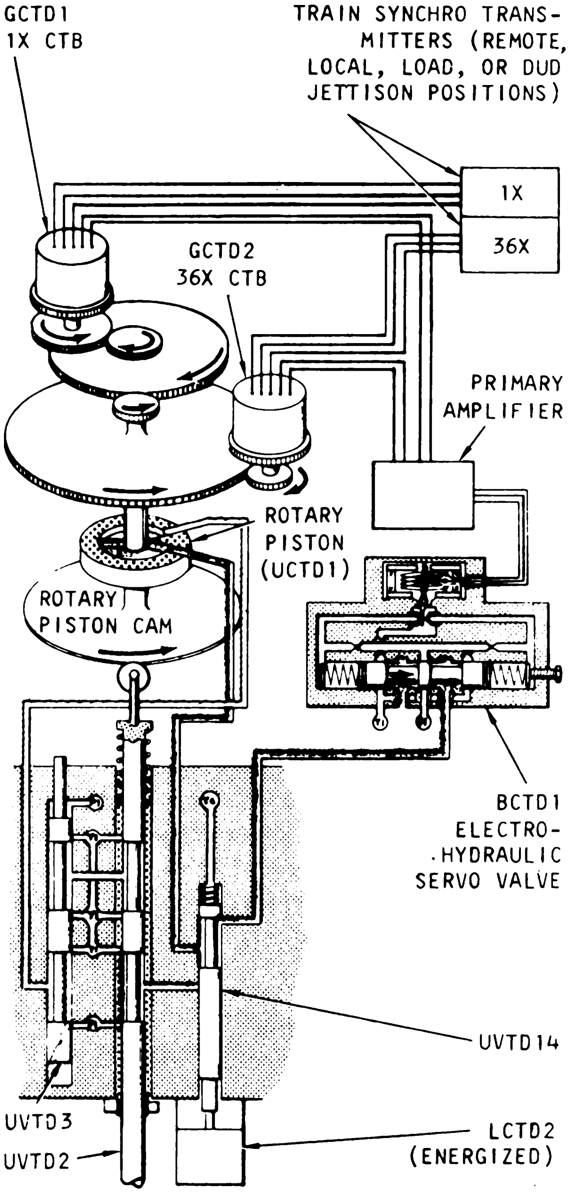
In illustration #14-29 it can be seen that two hydraulic chambers are formed between the piston stop and the rotary-piston vane and that a fluid port is located on each side of the piston stop. One of these two ports receives regulated pressure (200 psi) from UVTD3; the other port receives primary control pressure (0-400 psi) from BCTD1 or neutralizing control pressure (0-400 psi) from UVTD2. When the pressures in the two chambers are equal, the rotary piston vane remains stationary; however, when the control pressure from BCTD1 is lower than 200 psi, the vane moves toward the control chamber, or counterclockwise. (Refer to illustration #14-30 on the following page.) When the control pressure exceeds 200 psi, the vane moves away from the control chamber, or clockwise. The rotary-piston vane movement is transmitted by a shaft to the rotary-piston cam and, by means of shafting and gearing, to



14-29. INTERIOR OF ROTARY PISTON CYLINDER



14-28. NEUTRALIZING THE PRIMARY SERVO SYSTEM the rotors of the 1-speed and 36-speed CTB's.



14-30. RIGHT TRAIN OPERATION OF PRIMARY SERVO SYSTEM

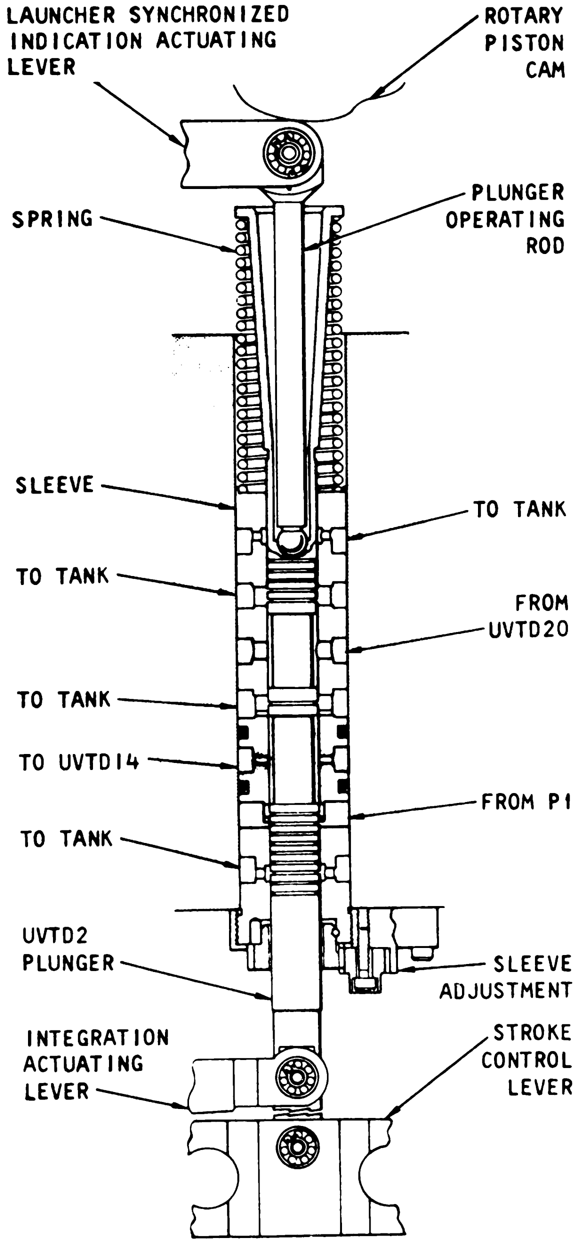
UVTD2, the rotary piston neutralizing valve, is a cam-operated, spring-returned, spool-type valve. (Refer to illustration #14-30.) One end of this valve is spring-loaded against the rotary-piston cam; the other end is connected to the stroke-control and integration actuating lever. During normal operation, UVTD2 is primarily used to transmit the output (primary stroke) of the primary servo to the stroke servo and integration systems.

In addition to transmitting the primary stroke, UVTD2 also performs the following functions:

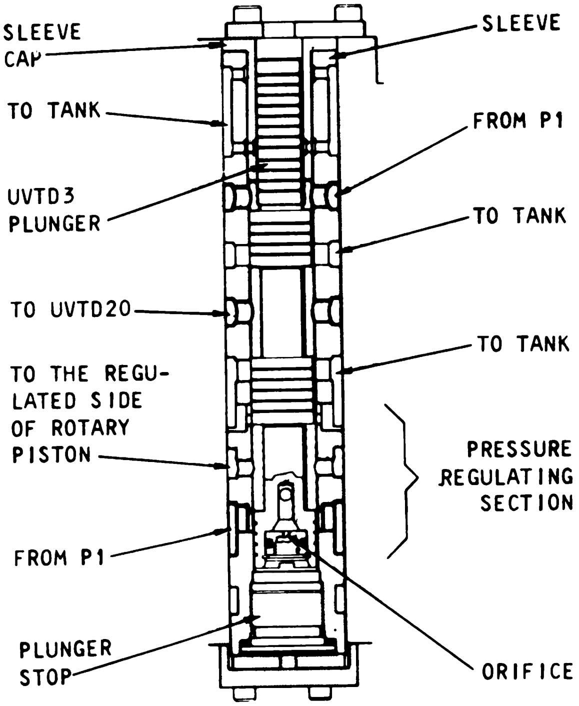
1. The lower chamber of UVTD2 acts as a pressure-dividing valve to neutralize the rotary piston when the power drive is being started or when a power failure occurs. If a power failure should occur when a right train or elevation signal is being applied, UVTD2 would be below its neutral position and the neutralizing control pressure would be higher than 200 psi. (Refer to illustrations #14-28 and #14-30.) After LCTD2 is deenergized, this neutralizing pressure would be applied, through UVTD14, to the rotary piston control chamber, causing the rotary piston to return to neutral.

2. The upper chamber of UVTD2 neutralizes the integration system by connecting the chamber below UVTD20 to tank whenever the B-end error exceeds 1°.

UVTD3, the pressure regulator



14-31. UVTD2



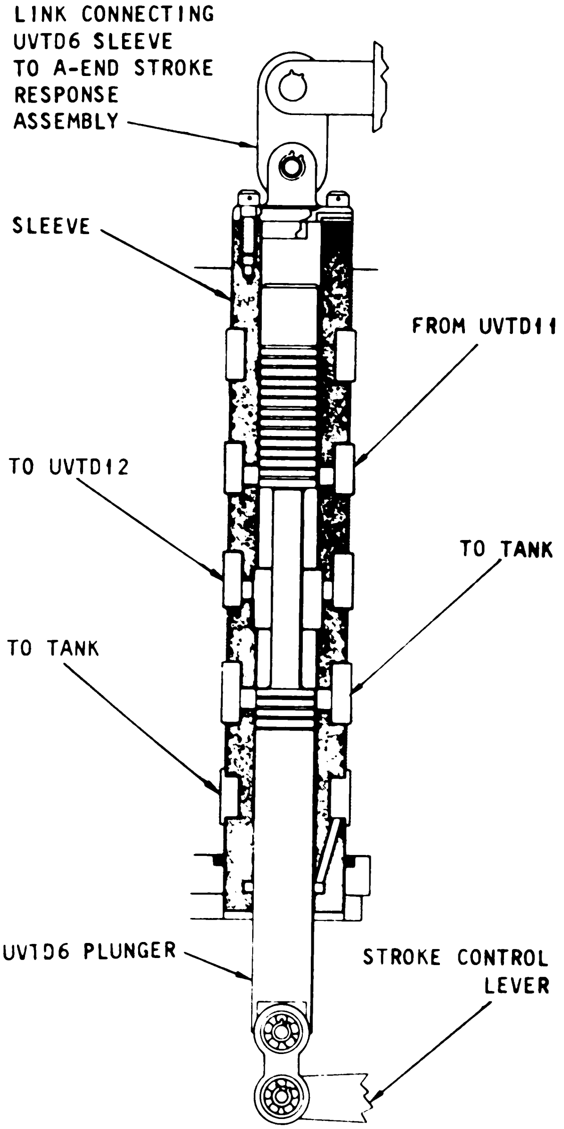
14-32. UVTD3

and integration cutout valve, is a two-chamber, spool-type, hydraulically balanced valve. (Refer to illustration #14-32.) With P1 (400 psi) on the top (small area side) and regulated pressure (200 psi) connected through an orifice from its lower chamber to the bottom (large area side), UVTD3 always centers itself.

The lower chamber of UVTD3 is connected by its center port to the regulated side of the rotary piston. The lower chamber maintains the pressure in the regulated side of UCTD1 at 200 psi. When tilt is applied for right train (refer to illustration #14-30), the pressure in the regulated side of the rotary piston is maintained in the following manner: The control-chamber pressure drops below 200 psi, causing the vane to rotate counterclockwise, thereby increasing the area in the regulated chamber. The increased area in the regulated side of UCTD1 causes a pressure drop in its regulated chamber. This pressure drop is felt in the lower chamber of UVTD3 and is transmitted through the orifice to the bottom of UVTD3. With 400 psi on the small area side (top) of UVTD3, UVTD3 moves down, connecting P1 (400 psi) pressure to its lower chamber. As the regulated pressure returns to 200 psi, UVTD3 moves up to its neutral position (its lower chamber is then equally connected to servo and tank).

When tilt is applied for left train or depression, the regulated pressure tends to increase and UVTD3 moves up, connecting its lower chamber to tank until the regulated pressure is normal again. Thus the movement of UVTD3, which is caused by the pressure-regulating action, can be used as a means to measure the speed of the rotary-piston movement (primary error-rate).

The upper chamber of UVTD3 neutralizes the integration system whenever the rotary piston error-rate exceeds 5° per second, by connecting the bottom of UVTD20 to tank.

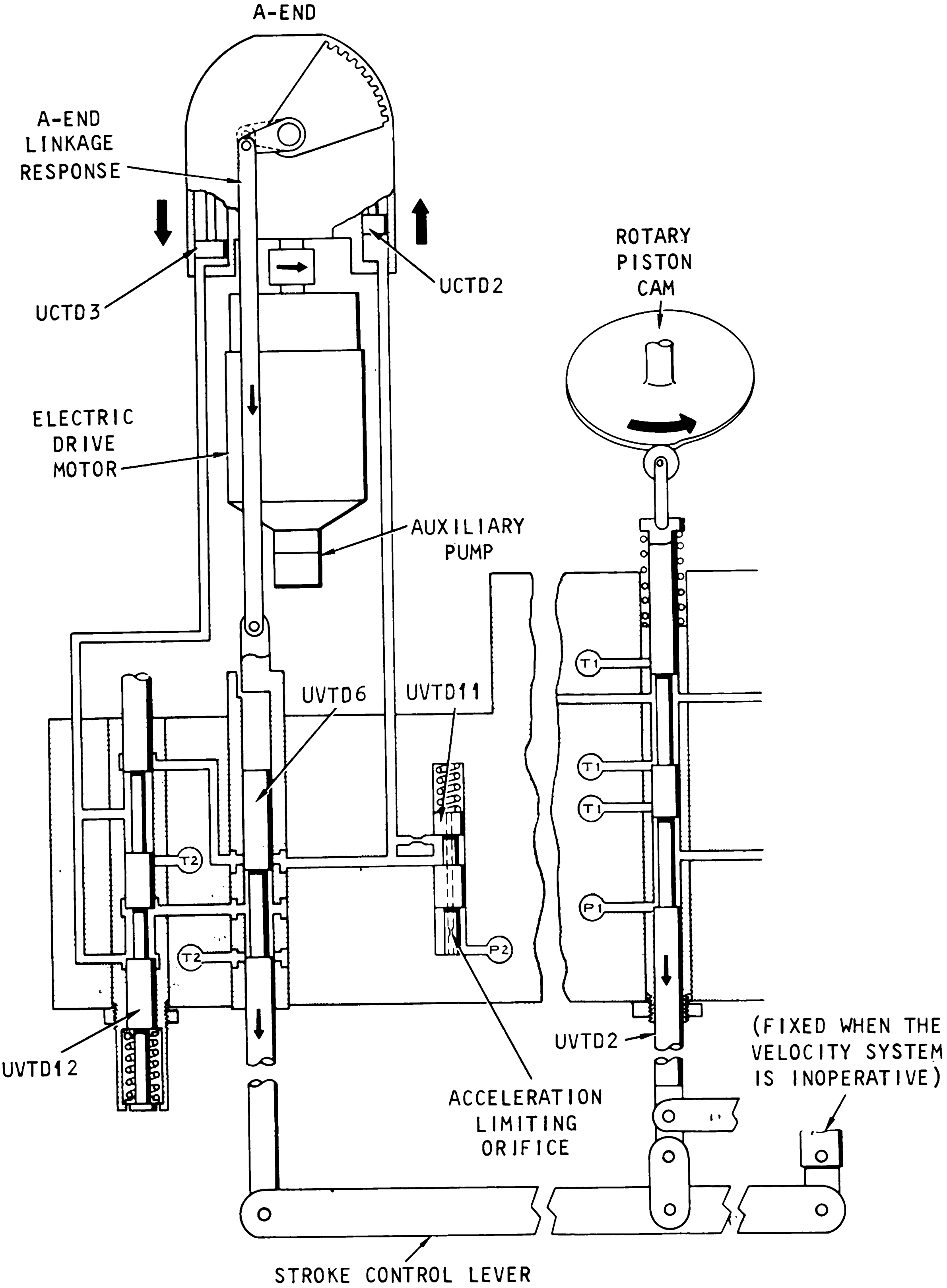


14-33. UVTD6

UVTD6, the stroke servo-valve, is a one-chamber, mechanically operated, spool-type valve with a movable sleeve. (Refer to illustration #14-33.) The valve plunger is positioned by the stroke control-lever, and the valve sleeve is positioned by A-end response.

UVTD6 controls the stroke of the A-end by regulating the control pressure ported to the large area stroking piston UCTD3. When the valve plunger and sleeve are on neutral in relation to the valve block, the pressure to UCTD3 is 200 psi and the A-end tilt-plate is on neutral.

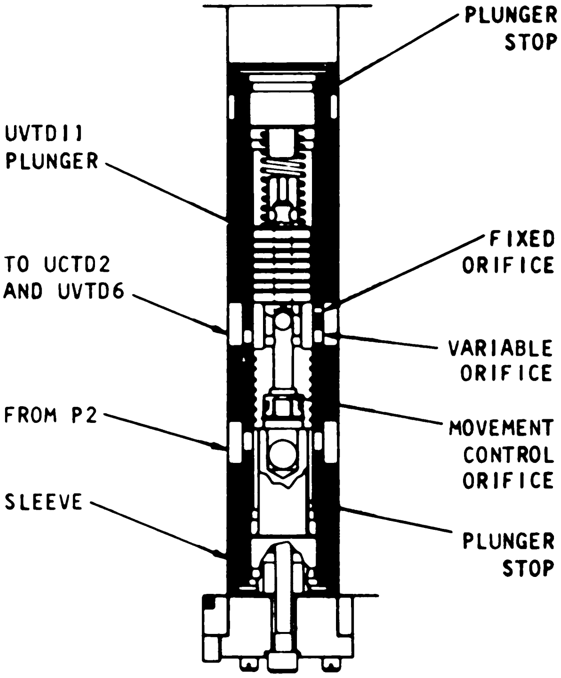
A signal to apply tilt for right train causes the plunger of UVTD6 to move down. (Refer to illustra-



14-34. RIGHT TRAIN OPERATION OF STROKE SERVO SYSTEM tion #14-34 on the preceding page.) This movement opens the tank port to the chamber of UVTD6 and causes the pressure ported to UCTD3 to drop below 200 psi, thereby applying tilt for right train.

The A-end tilt causes the sleeve of UVTD6 to move down, thus returning the chamber pressure to 200 psi and preventing further A-end tilt movements until another input order is received by the plunger of UVTD6.

The order to remove right train tilt or to apply left train tilt reverses the movement of the valve plunger and sleeve, causing the control pressure to rise above 200 psi. (Refer to illustration #14-33.)



14-35. UVTD11

The stroking pistons UCTD2 and UCTD3 function to physically apply A-end tilt. UCTD2, the small area stroking piston, always receives servo pressure of 400 psi. UCTD3, the large area stroking piston, receives control pressure (0-400 psi) from the valve chamber of UVTD6. The pistons are balanced so that they cannot apply any tilt to the A-end with 400 psi on the small area piston and 200 psi on the large area piston. (These pistons are shown in illustration #14-34.)

UVTD11, the train acceleration limiting valve, limits launcher acceleration in train to 60° per second/per second. (Refer to illustration #14-35.) The elevation power drive is limited by UVED11 to 40° per second/per second.

Note that acceleration depends on the speed at which the stroke is applied to the A-end tilt-plate. Since the rate of fluid flow to the A-end stroking pistons determines the speed of tilt-plate movement, the maximum acceleration rate can be limited by a flow control valve (for instance, UVTD11).

During normal operation, servo pressure at 400 psi enters the bottom of UVTD11, flows through the plunger passage to the top, and acts there, in conjunction with the spring, to force the plunger down. With the plunger in the down position, the variable orifice and fixed orifice are open and allow fluid flow to the stroking pistons. (Refer to illustrations #14-34 and #14-35.)

If an instantaneous demand for a large volume of fluid (high acceleration) is placed on UVTD11, the valve reduces its output flow in the following manner:

The demand for fluid which causes a pressure drop is felt sooner on top (spring side) than on the bottom of the valve due to the action of the movement control-orifice in the drilled passage of the valve.

As the pressure on top of the valve-plunger decreases, the fluid pressure on the bottom forces the plunger up, thereby reducing the size of the variable orifice and limiting the valve output. If the demand on UVTD11 is exceedingly heavy, the fluid flow through the variable orifice is cut off completely and all fluid must pass through the fixed orifice.

In the remainder of this topic, the operation of the receiver regulator when the launcher is synchronizing with and following a moving director will be explained.

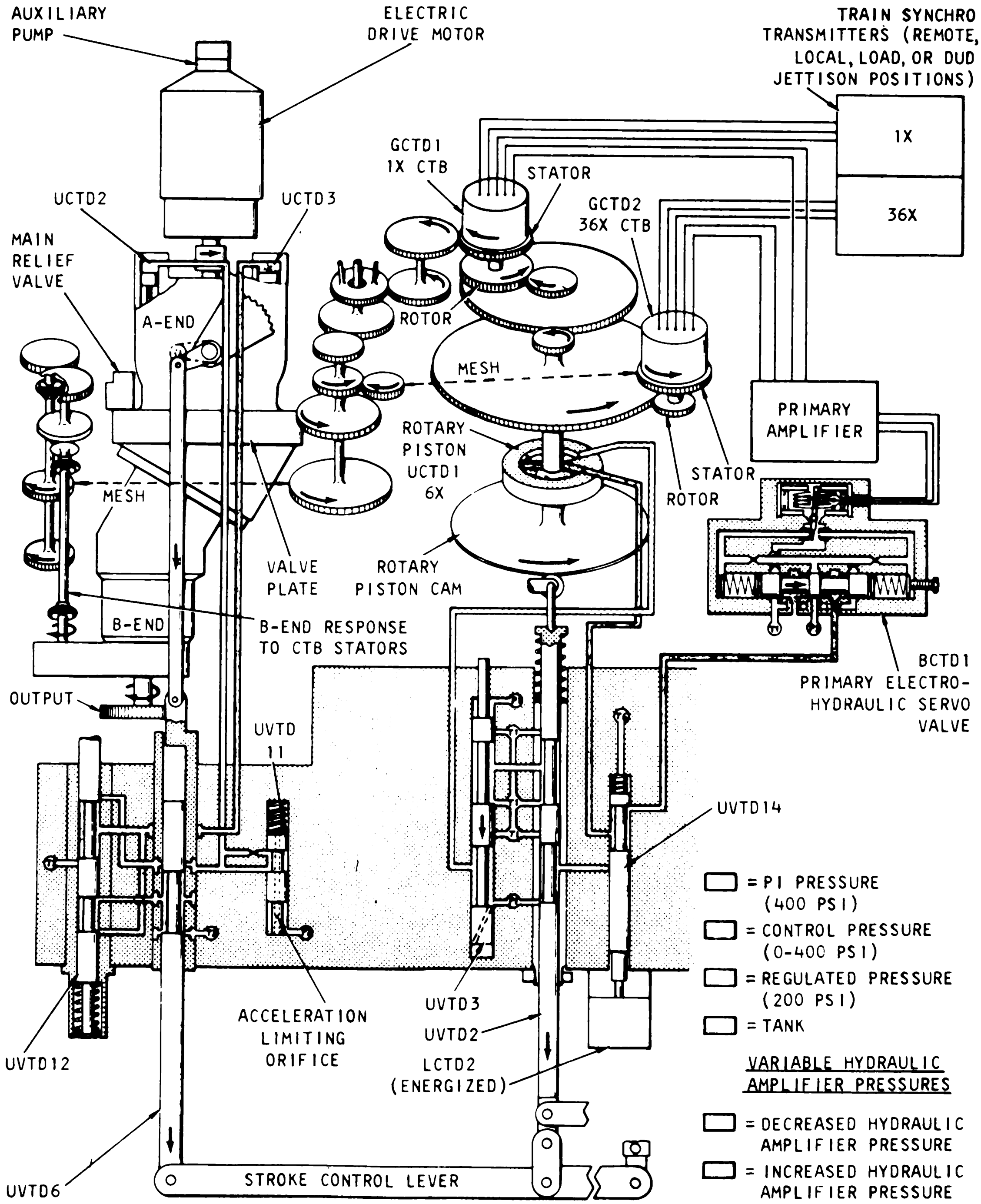
When the launcher is assigned, the director is 90° away from the launcher, and the director is training right at 10° per second. (The launcher is at 180° and the director at 270°.)

It is assumed that only the primary control system is functioning to control the launcher .

NOTE: It is possible but not normal for the launcher to follow a dynamic signal in primary control; however, it is normal for the launcher when it is training and depressing to the load position to operate in primary control only. Also, the launcher operates only in primary control when synchronizing with a stationary director. At the same time, velocity control, although available, is not utilized, because the director tachometer-generator is not producing any output.

The primary amplifier transmits the right-train error-signal to the electrohydraulic servo valve BCTD1 and causes the force-motor reed to move in the direction shown in illustration #14-36 on the following page. This reed movement decreases the flow through the left nozzle (N1), thus increasing the flow through the right nozzle (N2). The resulting differential pressure moves the plunger of BCTD1 to the right. (Refer to illustration #14-36.)

As the plunger moves right against the spring, the servo-fluid (400 psi) port is closed and the tank port is opened to the right chamber of BCTD1. The primary control pressure therefore drops to below 200 psi. This pressure is transmitted, via UVTD14 (solenoid-


AUXILIARY PUMP
ELECTRIC DRIVE MOTOR
TRAIN SYNCHRO TRANSMITTERS (REMOTE, LOCAL, LOAD, OR DUD JETTISON POSITIONS)
1X
36X
GCTD1 1X CTB
STATOR
GCTD2 36X CTB
UCTD2
UCTD3
MAIN RELIEF VALVE
A-END
ROTOR
MESH
PRIMARY AMPLIFIER
ROTARY PISTON UCTD1 6X
STATOR
ROTOR
MESH
VALVE PLATE
ROTARY PISTON CAM
B-END
B-END RESPONSE TO CTB STATORS
BCTD1 PRIMARY ELECTRO-HYDRAULIC SERVO VALVE
OUTPUT
UVTD 11
UVTD14
☐ = PI PRESSURE (400 PSI)
☐ = CONTROL PRESSURE (0-400 PSI)
☐ = REGULATED PRESSURE (200 PSI)
☐ = TANK
VARIABLE HYDRAULIC AMPLIFIER PRESSURES
☐ = DECREASED HYDRAULIC AMPLIFIER PRESSURE
☐ = INCREASED HYDRAULIC AMPLIFIER PRESSURE
ACCELERATION LIMITING ORIFICE
UVTD3
UVTD2
LCTD2 (ENERGIZED)
UVTD12
UVTD6
STROKE CONTROL LEVER

14-36. RIGHT TRAIN OPERATION OF THE POWER DRIVE SERVO SYSTEM energized), to the rotary piston.

With a pressure decrease in the control chamber of the rotary piston UCTD1 and regulated pressure (200 psi) in the other chamber, UCTD1 rotates in a counterclockwise direction. (Refer to illustration #14-36.) Due to the 90° error existing between the launcher and director, the rotary piston rotates counterclockwise into its stop.

As the rotary piston rotates, it accomplishes the following actions:

1. Positions the rotors of the CTB's (1-speed and 36-speed) in such a direction that 25° of the error signal applied to the amplifier is canceled.

2. Rotates its (rotary piston) cam and causes UVTD2 to move down. (Refer to illustration #14-36.) The downward movement of UVTD2 is transmitted through the stroke control-lever to the plunger of UVTD6, causing it to move down. (Refer to illustration #14-35.)

As the plunger of UVTD6 moves down (out of its sleeve), the tank port is opened and the servo-pressure port is closed, causing the control pressure in the valve chamber to decrease. This control pressure is ported, via the lower chamber of UVTD12, to the large area stroking piston UCTD3.

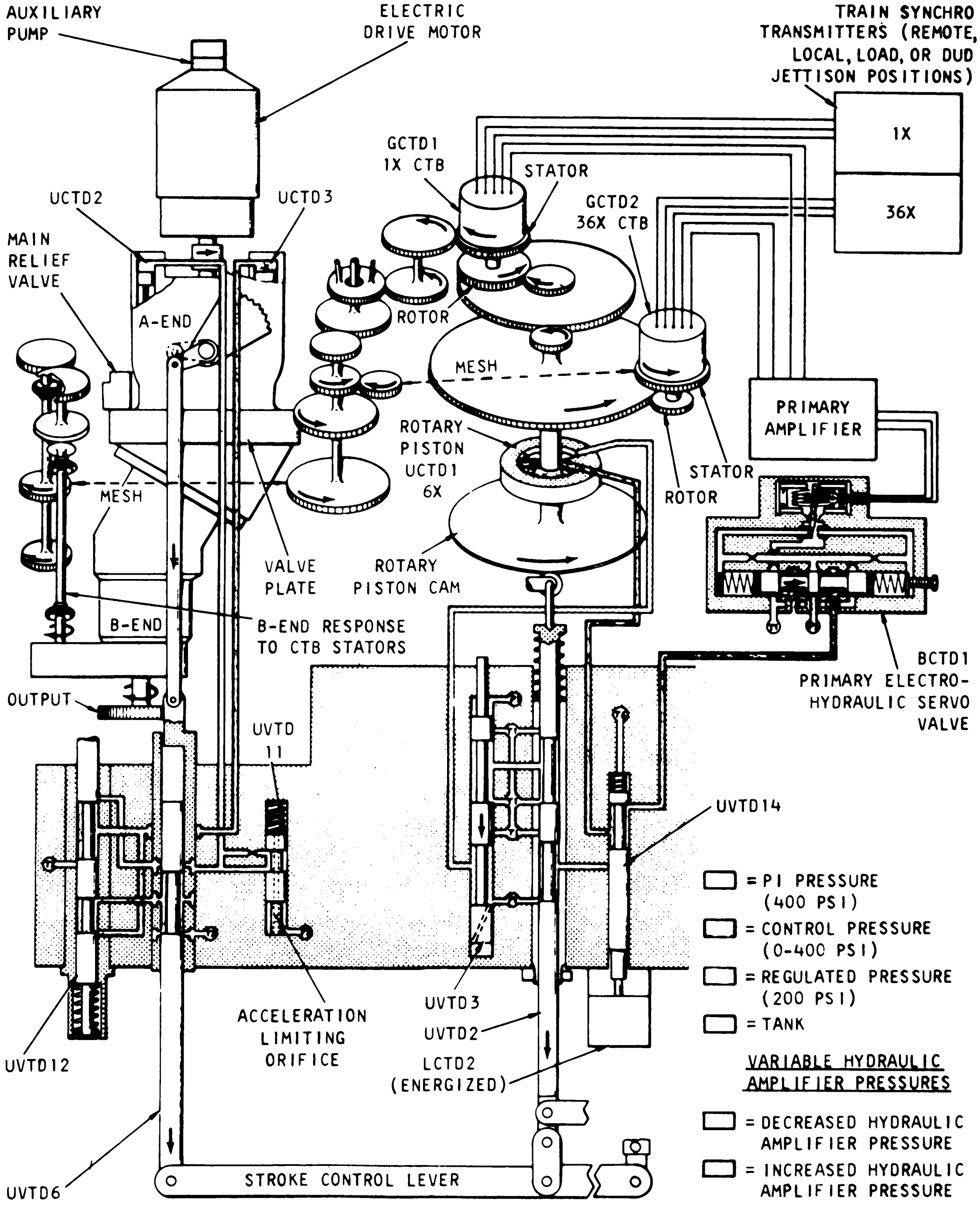
With the control pressure on UCTD3 below 200 psi and the servo pressure on small stroking piston UCTD2 at 400 psi, A-end stroke is applied to cause the launcher to train to the right. The application of A-end stroke causes the sleeve of UVTD6 to move down until the control pressure to UCTD3 again reaches 200 psi. However, the A-end is on full primary stroke due to the large error existing between launcher and director position.

The launcher is now traveling at full speed, the A-end is fully tilted, the sleeve and plunger of UVTD6 are neutralized with regard to each other, but displaced from their neutral position in the valve block, UCTD1 is rotated fully (150°) counterclockwise, and the plunger of BCTD1 is displaced to the right.

When the launcher reaches a point 25° from being synchronized with the director, the electrical output (error signal) of the controlling CTB (36-speed) reaches zero. As the B-end response drives the stators past this point, the phase of the error signal is reversed and this reversed-phase error signal is transmitted through the primary amplifier to BCTD1.

NOTE: The electrical zero-point (false synchronization) is reached 25° before proper (true) synchronization takes place, because the rotary piston when it is going on stroke cancels 25° of the error signal.

The reversed error signal forces the reed of BCTD1 to pivot past neutral in the opposite direction of the


AUXILIARY PUMP
ELECTRIC DRIVE MOTOR
TRAIN SYNCHRO TRANSMITTERS (REMOTE, LOCAL, LOAD, OR DUD JETTISON POSITIONS)
1X
36X
GCTD1 1X CTB
STATOR
GCTD2 36X CTB
UCTD2
UCTD3
MAIN RELIEF VALVE
A-END
ROTOR
MESH
PRIMARY AMPLIFIER
ROTARY PISTON UCTD1 6X
STATOR
ROTOR
MESH
VALVE PLATE
ROTARY PISTON CAM
B-END
B-END RESPONSE TO CTB STATORS
BCTD1 PRIMARY ELECTRO-HYDRAULIC SERVO VALVE
OUTPUT
UVTD 11
UVTD14
= PI PRESSURE (400 PSI)
= CONTROL PRESSURE (0-400 PSI)
= REGULATED PRESSURE (200 PSI)
= TANK
VARIABLE HYDRAULIC AMPLIFIER PRESSURES
= DECREASED HYDRAULIC AMPLIFIER PRESSURE
= INCREASED HYDRAULIC AMPLIFIER PRESSURE
ACCELERATION LIMITING ORIFICE
UVTD3
UVTD2
LCTD2 (ENERGIZED)
UVTD12
UVTD6
STROKE CONTROL LEVER

14-37. RIGHT TRAIN OPERATION OF THE POWER DRIVE SERVO SYSTEM (same as 14-36) one shown in illustration #14-36, causing the primary control pressure, which now exceeds 200 psi, to be transmitted from BCTD1 to the control chamber of the rotary piston.

The rotary piston now starts rotating clockwise from the full counterclockwise position. However, the launcher continues to drive at maximum velocity until it has reached a point in train 13.5° (elevation 11.33°) from synchronization with the moving director.

NOTE: The rotary piston cam is cut so that only the last 81° of cam movement in either direction from the neutral position cause the launcher to decelerate.

When the launcher reaches 13.5° from synchronization with the director, the rotary-piston cam causes UVTD2 to move up. This movement of UVTD2 is transmitted by the stroke control-lever to UVTD6. The upward movement of the UVTD6 plunger causes an increase in the control pressure to UVTD3, and the A-end stroke is being removed. The sleeve of UVTD6 follows the upward movement of the valve plunger as the A-end stroke is being removed.

The launcher continues to decelerate until it is synchronized with and is moving at the same speed (10° per second) as the director. BCTD1 is now on neutral because there is no error signal, and the control pressure to UCTD1 is at 200 psi.

UCTD1, however, is still rotated counterclockwise from neutral. This rotation of UCTD1 is equivalent to 10° per second of launcher movement. UVTD2 and the stroke control lever are still below their neutral position. The plunger and sleeve of UVTD6 are neutralized with regard to each other, but below their neutral position in the valve block. The control pressure from UVTD6 is at 200 psi, holding the stroke piston displaced a distance equal to 10° per second of launcher movement.

When the director decelerates to a stop, the reed of BCTD1 again moves away from neutral, causing the control pressure to exceed 200 psi. UCTD1 rotates clockwise toward neutral, and the plunger of UVTD6 moves up. With the control pressure above 200 psi, UCTD3 moves to remove right train-stroke. When the director stops, the error between launcher and director is zero and all primary and stroke servo components are neutralized.

QUIZ SHEET:

1. Servo pressure (P1 and P2) is maintained

    a. At 100 psi.
    b. At 200 psi.
    c. At 400 psi.
    d. Between 0 and 400 psi.

2. When the reed of BCTD1 pivots to restrict fluid flow from noznozle N2, primary control pressure increases to above 200 psi.

    True ______ or False ______.

3. If the pressure in the control chamber of UCTD1 exceeds 200 psi, the rotary-piston cam rotates counterclockwise. (See illustration #14-35.)

    True ______ or False ______.

4. UVTD14 neutralizes the rotary piston when

    a. The launcher is synchronized with the director.
    b. The launcher is assigned to a director.
    c. The limit stops actuate.
    d. A power failure occurs.

5. When the launcher is training right in primary control, the pressure in the lower chamber of UVTD2 exceeds 200 psi.

    True ______ or False ______.

6. The upper chamber of UVTD3 neutralizes the integration system whenever the error rate of the rotary piston exceeds

    a. 1° per second.
    b. 4.8° per second.
    c. 5° per second.
    d. 13.5° per second.

7. Pressure in the chamber of UVTD6 cannot be maintained at 200 psi unless both the valve plunger and sleeve are on neutral in relation to the valve block.

    True ______ or False ______.

8. UVTD11 limits the speed of the stroke to be applied to the train power-drive A-end by directly controlling the flow of

    a. Servo pressure.
    b. Control pressure.
    c. Regulated pressure.
    d. Supercharge pressure.

9. How many degrees of the error signal are canceled when the rotary piston rotates into its stop?

    a. 13.5°.
    b. 25°.
    c. 29.8°.
    d. 81°.

10. When the launcher is following a director in left train, and there is a zero error signal, the following action takes place:

    a. The reed of BCTD1 is on neutral.
    True _____ or False _____.
    b. Primary control pressure is at 200 psi.
    True _____ or False _____.
    c. Rotary piston is on neutral.
    True _____ or False _____.
    d. Pressure in chamber of UVTD6 is at 200 psi.
    True _____ or False _____.

TOPIC 5: TRAIN VELOCITY AND INTEGRATION SYSTEMS

You Are Now Going To Learn:

1. Velocity servo system operation.
2. Integration system operation.

Discussion Points For This Topic Are:

1. Velocity signal.
2. Velocity and integration electrohydraulic servo valve BCTD2.
3. Velocity and integration cutout valve UVTD10.
4. Velocity piston UCTD7.
5. Velocity neutralizing valve UVTD9.
6. Velocity potentiometer RATD1.
7. Velocity system operation.
8. Integration control valve UVTD7.
9. Integration neutralizing valve UVTD20.
10. Integration piston UCTD8.
11. Integration piston neutralizing valve UVTD8.
12. Integration potentiometer RATD2.
13. Integration system operation.
14. Launcher operation with dynamic signals.
15. Review and summary.
16. **Written test.**

INFORMATION AND DISCUSSION:

The velocity signal for remote (automatic) launcher operation is originated by a tachometer generator located in a computer; for local control, the velocity signal is originated in a missile launching system control-panel. The dummy directors used for testing the power drives also have tachometer generators installed. The tachometer generators (rate generators) are geared and produce an output of approximately one volt per degree per second.

The generator is designed with a fixed permanent magnet which acts as a field for the generator and a bearing-mounted rotatable armature. When the armature is driven, the generator output voltage is proportional to the rotation speed of the armature. The output voltage of the generator changes polarity when the armature of the generator reverses its direction of rotation; therefore, its output voltage also differentiates between direction of the order signals. Thus, the output voltage (rate signal) of the generator indicates the speed and direction of launcher order-signals.

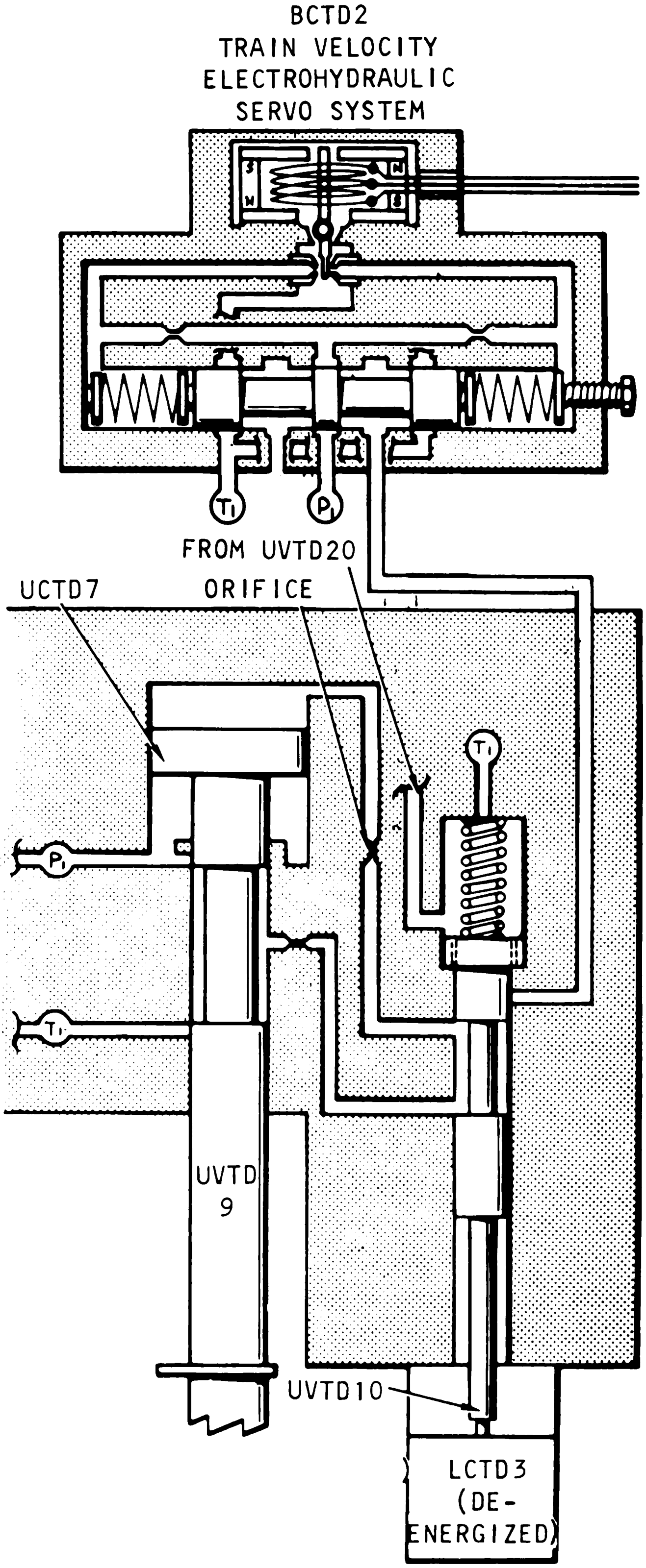
A magnetic amplifier is used to differentiate between increasing and decreasing velocity orders and to amplify the velocity signal, to enable the output of the amplifier to control the velocity electrohydraulic servo-valve.

BCTD2, the velocity electrohydraulic servo valve, is identical in construction and operation with the primary electrohydraulic servo valve BCTD1, except that BCTD2 positions a linear moving piston instead of a rotary piston.

The velocity rate signal for right train and elevation causes the control pressure to decrease below 200 psi; the velocity rate signal for left train or depression causes the control pressure to increase above 200 psi.

UVTD10, the velocity and integration cutout valve, is a solenoid (LCTD3)-operated, three-land, spring-returned valve which actuates the velocity and integration neutralizing systems when LCTD3 is deenergized and ports velocity servo pressure from BCTD2 to the velocity piston.

When LCTD3 is deenergized, the pressure from BCTD2 to UVTD10 is blocked. The pressure from the velocity neutralizing valve UVTD9 is now ported to the top of the velocity piston UCTD7, causing the piston to return to its neutral position. Note that the hydraulic line from UVTD20 is connected to tank, causing the integration system also to neutralize. (Refer to



14-38. VELOCITY SYSTEM NEUTRALIZED

illustration #14-38 on the preceding page.)

When LCTD3 is energized, UVTD10 is moved up, blocking the pressure port from the velocity neutralizing valve and connecting servo pressure from BCTD2 to the velocity piston. The upper land of UVTD10 at this time blocks the line from UVTD20.

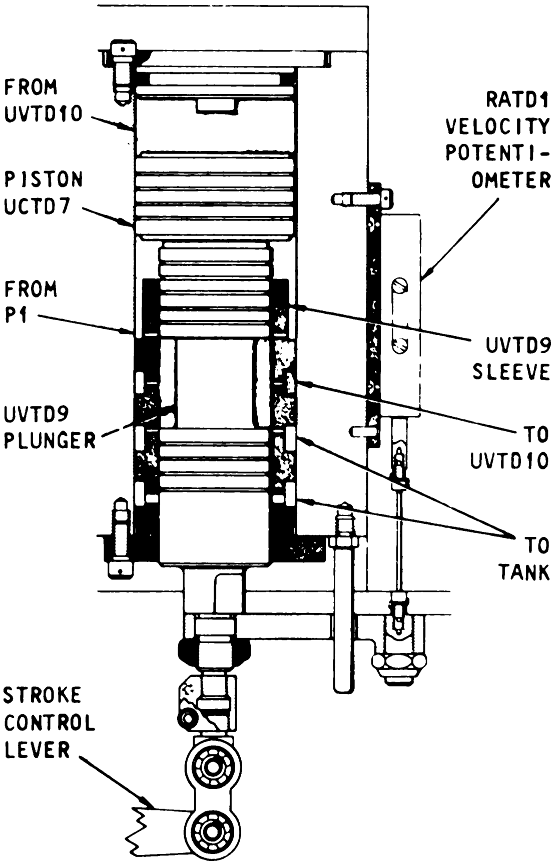
LCTD3 is energized whenever the launcher is training toward or following a remote signal and is de-energized when the launcher is being started, when power failures occur, and when the launcher is returning to the load position.

UCTD7, the velocity piston, is hydraulically displaced to position the stroke control-lever in proportion with the velocity order. This piston and the velocity-piston neutralizing valve UVTD9 are machined as one piece; however, during normal dynamic operation, the valve functions only as a connecting link between the piston and the stroke control lever.

The lower (small area) chamber of UCTD7 is always connected to servo pressure (400 psi). The upper (large area) chamber of the piston is either connected to velocity control-pressure (0-400 psi) from BCTD2 or to neutralizing control-pressure from UVTD9.

UCTD7 remains stationary whenever control pressure on top of the piston is 200 psi.

When a velocity signal for right train is applied, the pressure on top of the piston decreases and the piston moves up. A left train velocity signal causes the pressure in the upper chamber to increase, moving the piston down. (Illustration #14-39 shows the arrangement of UCTD7.)



14-39. UCTD7, UVTD9, AND RATD1

UVTD9, the velocity neutralizing valve, neutralizes UCTD7 when LCTD3 is deenergized. When the velocity piston is on neutral, the chamber of UVTD9 is connected equally to servo pressure (400 psi) and to tank (0 psi).

Whenever UCTD7 is above its normal position as LCTD3 deenergizes, pressure from the chamber of UVTD9 is over 200 psi, causing UCTD7 to return to its neutral position; when the valve and piston are below their normal position, neutralizing control-pressure is below 200 psi until the valve and piston return to neutral.

RATD1, the train velocity potentiometer, feeds a velocity-piston response-signal to the velocity amplifier. This signal cancels the order signal when the velocity piston has moved the ordered distance. (Refer to illustration #14-39.)

The wiper of the potentiometer is mechanically connected to the velocity piston. The voltage picked off by the wiper is proportional in amplitude to the piston displacement from its neutral position.

In the following explanation of velocity servo operation it will be assumed that the director is moving in right train, that the launcher is training right to synchronize with the director, and that the integration system is inoperative.

The signal from the velocity amplifier causes the reed of BCTD2 and its valve plunger to move. (Refer to illustration #14-40 on the following page.) As a result, a velocity control-pressure of less than 200 psi is ported from BCTD2, via UVTD10, to the large area side (top) of UCTD7, causing UCTD7 and UVTD9 to move up.

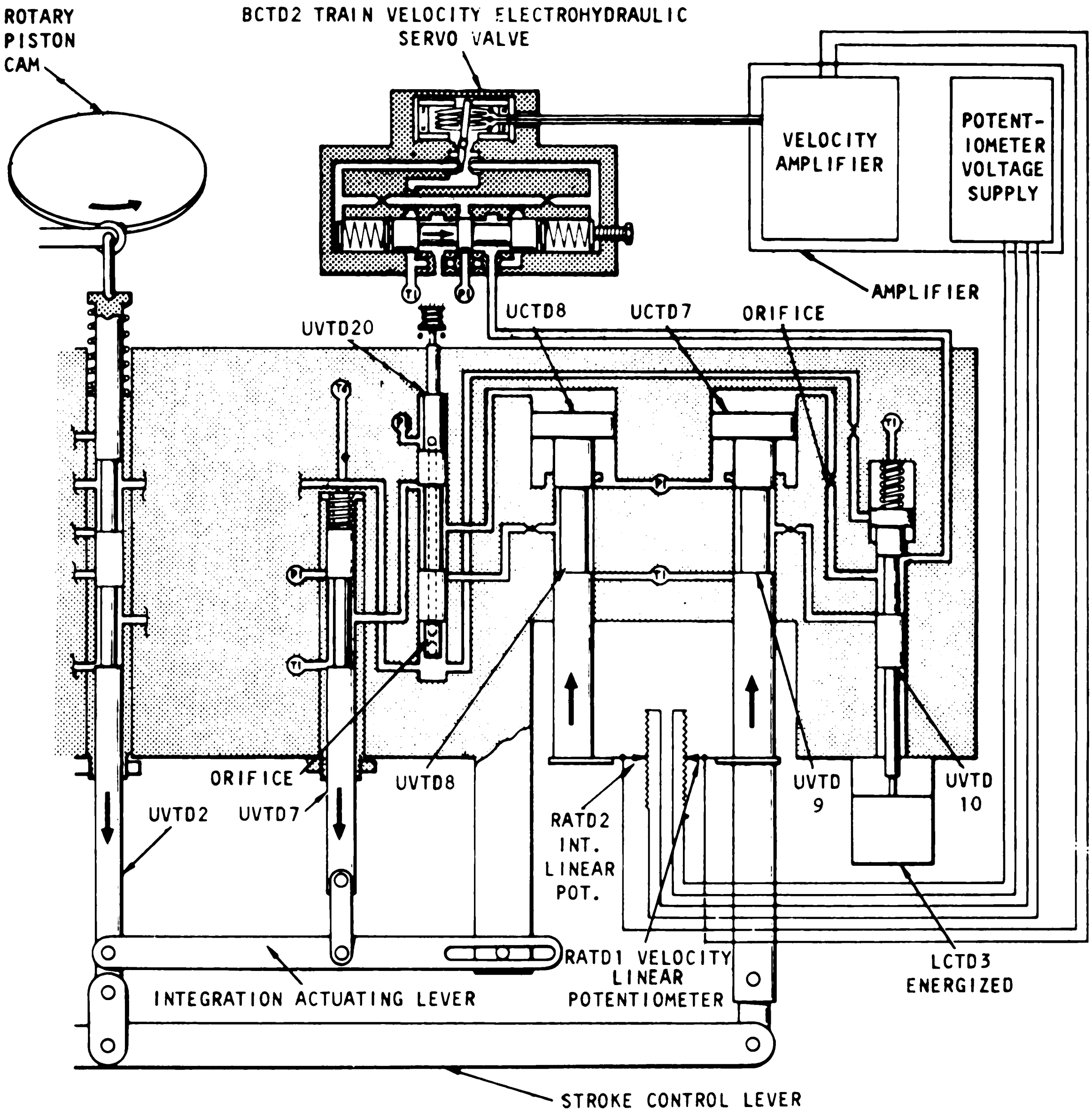
When UCTD7 moves up, a response signal, which is proportional in amplitude and in phase to piston movement, is transmitted from the wiper of RATD1 to the velocity amplifier.

When the response signal and the velocity-order input-signal are equal, the servo error is zero and BCTD2 returns to neutral. The velocity piston, however, remains in its displaced position until the director slows down or speeds up.

The upward movement of the velocity piston is also transmitted by UVTD9 to the stroke control-lever, causing the right end of the lever to move up. The pivot-point on the control lever is now located at UVTD2.

As UCTD7 moves up, UVTD6 moves down, to apply the right train-stroke to the A-end. Thus the velocity stroke adds to the primary stroke a signal which is proportional to the speed of the director.

NOTE: The velocity signal adds to the primary signal during synchronization when the launcher and director both are training right or left. However, if during synchronization the launcher and director are moving toward each other, the velocity signal subtracts from the primary signal.



▭ = PI PRESSURE (400 PSI)
▭ = CONTROL PRESSURE (0 TO 400 PSI)
▭ = TANK

VARIABLE HYDRAULIC AMPLIFIER PRESSURES

▭ = DECREASED HYDRAULIC AMPLIFIER PRESSURE
▭ = INCREASED HYDRAULIC AMPLIFIER PRESSURE

14-40. VELOCITY AND INTEGRATION SYSTEMS, RIGHT TRAIN OPERATION

The velocity-signal input is not affected when the launcher synchronizes with the director unless the director changes its speed. The velocity input, however, does affect the operation of the receiver regulator, because a small primary signal is required to maintain the A-end stroke.

As the launcher slows down and comes to a stop, the tachometer-generator signal decreases and the response signal from RATD1 becomes stronger than the tachometer-generator signal. This response signal is of such a phase that the reed of BCTD2 moves in the opposite direction of the one shown in illustration #14-40. The velocity control pressure now exceeds 200 psi, moving UCTD7 and the stroke control-lever down toward their neutral positions.

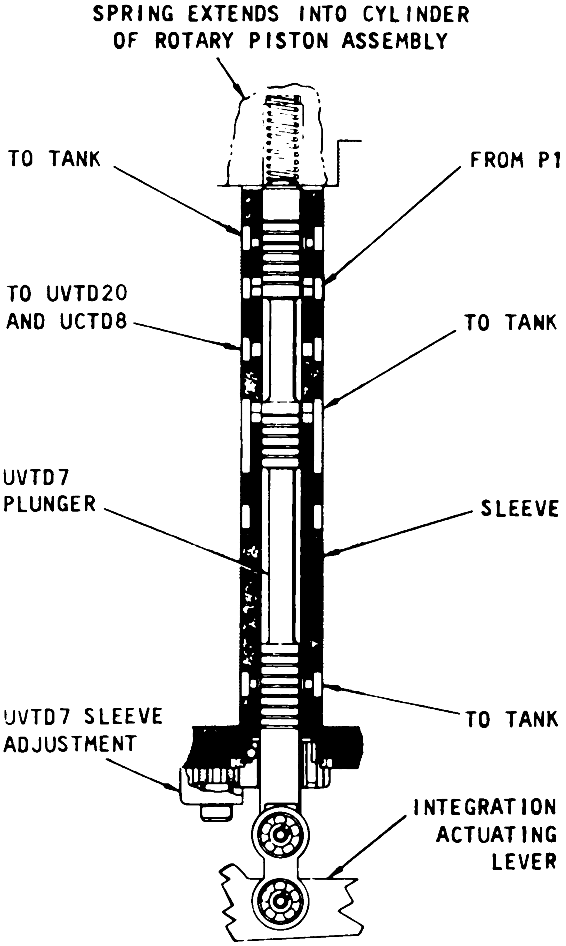
When the director stops, there is no velocity order signal; therefore, BCTD2 and UCTD7 are both on neutral.

The integration system improves the launcher operation when the launcher is following a dynamic signal. This signal is generated by the movement of UVTD2 (primary stroke).

The integration actuating lever (refer to illustration #14-40) transmits the movement of UVTD2 to the integration system. The electrical output of the integration system is then applied to the velocity amplifier where it is added to or subtracted from the velocity signal.

UVTD7, the integration control-valve, is mechanically positioned by the integration actuating lever and acts as a pressure-dividing valve. In its chamber it generates the integration control pressure (0-400 psi) which controls integration piston UCTD8 when the integration system is cut in.

When UVTD7 (refer to illustration #14-41 below) is on neutral, its chamber is connected equally to servo (400 psi) pressure and to tank

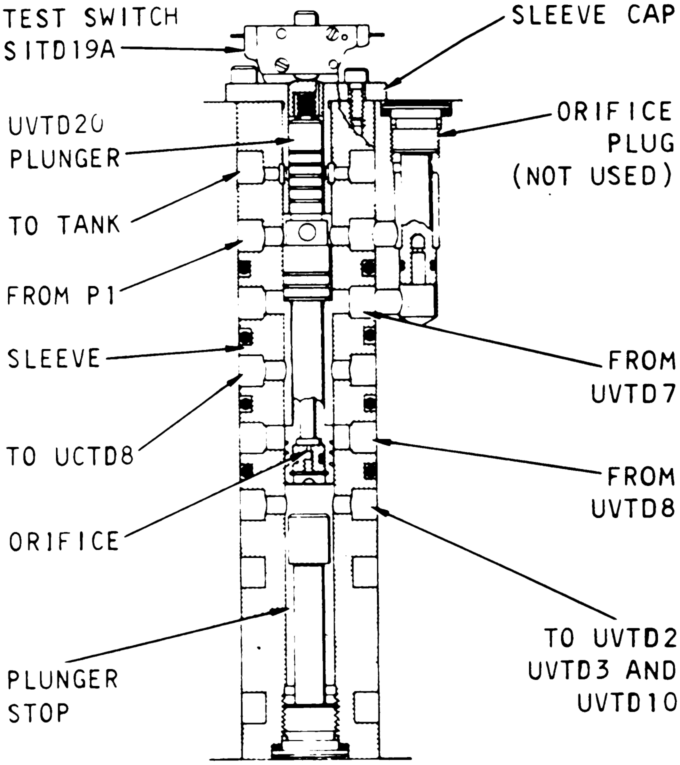


14-41. UVTD7

(0 psi) pressure. A primary right-train signal causes the pressure in the chamber of UVTD7 to decrease below 200 psi.

UVTD20, the integration neutralizing valve, is hydraulically actuated and ports either the integration servo control-pressure from UVTD7 or the integration neutralizing pressure from UVTD8 to the large area side of the integration piston UCTD8.

The servo pressure (400 psi) enters near the top (small area side) of UVTD20 (refer to illustration #14-42) and flows through a passage drilled through the center of the valve to its lower (large area) end. The orifice located in the valve base allows only a small amount of fluid to pass through the valve.



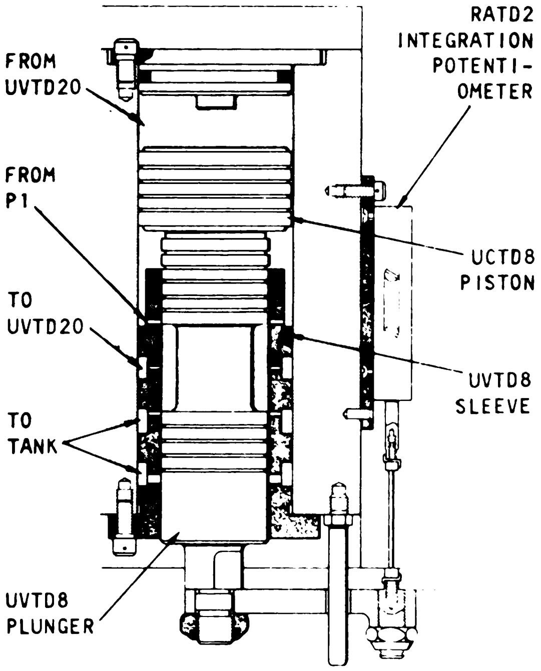
14-42. UVTD20

When the pressure at both ends of the valve is balanced, UVTD20 is up, thereby connecting the chamber of UVTD7 to the integration piston; when the pressure from the large area end of UVTD20 is connected to tank, UVTD20 moves down and shifts the control of the integration piston from UVTD7 to UVTD8.

Pressure from the large area end of UVTD20 can be connected to tank by either one of the following three valves:

1. Upper chamber of UVTD2 when the primary error exceeds 1°.
2. Upper chamber of UVTD3 when the primary error-rate exceeds 5° per second.
3. UVTD10 when LCTD3 is de-energized.

UCTD8, the integration piston, is constructed and operates according to the same principles as UCTD7. (Refer to illustration #14-43 on the following page.) The control pressure in the large area side (top) of UCTD8 is controlled by UVTD7 when the integration system is cut in and is controlled by UVTD8 when the integration system is neutralized. Any movement of UCTD8 is transmitted, through UVTD8, to position



14-43. UCTD8, UVTD8, AND RATD2

the wiper arm of the integration potentiometer RATD2.

UVTD8, the integration piston neutralizing valve, is machined as part of UCTD8. When the integration system is cut in, UVTD8 acts only as a connecting link between UCTD8 and RATD2. However, during neutralization of the integration system, the chamber of UVTD8 is connected, via UVTD20, to the large area side of UCTD8 and always returns UCTD8 to its neutral position. (Illustration #14-43 shows UCTD8 and UVTD8 in their neutral positions.)

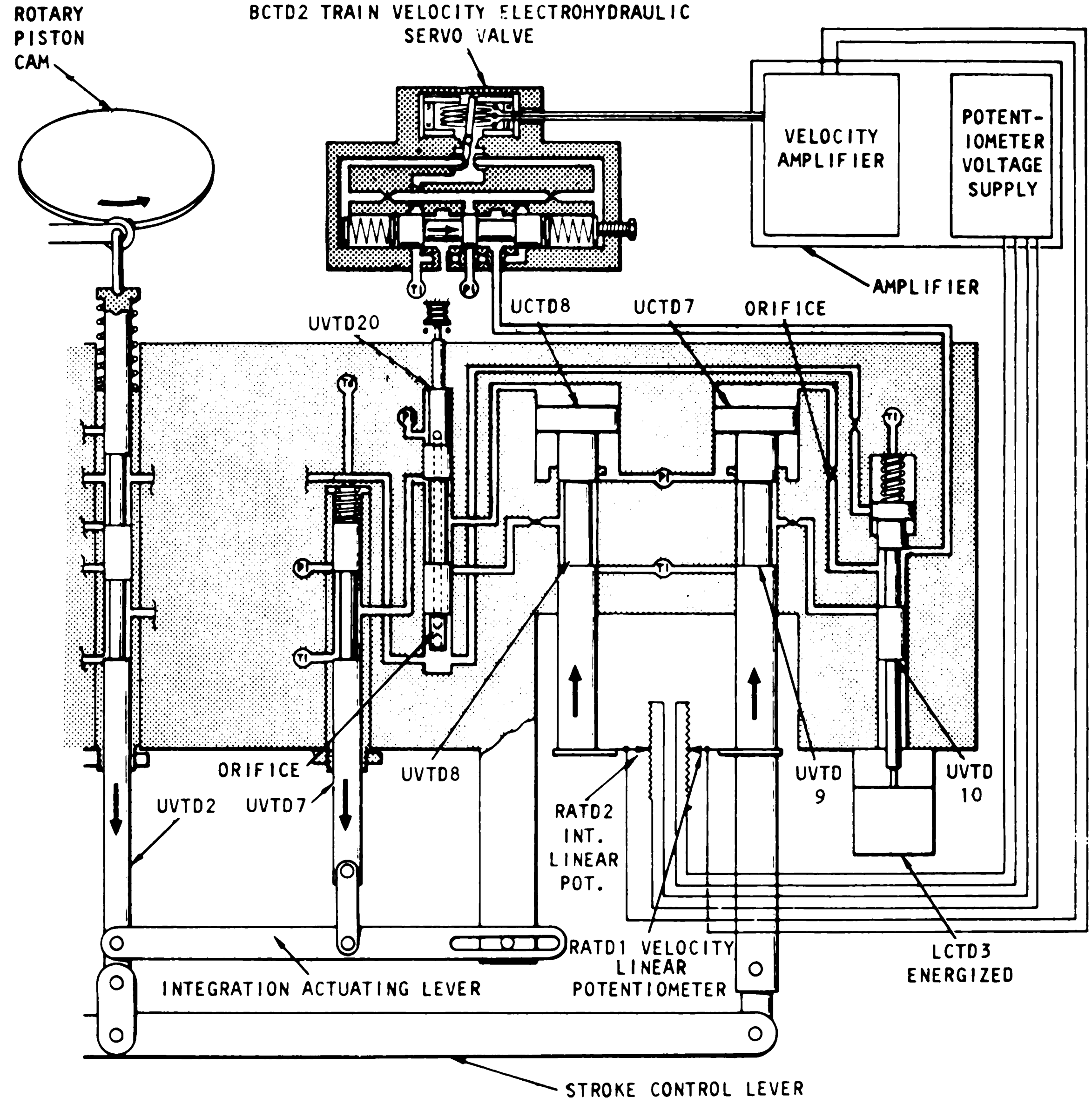
RATD2, the integration potentiometer, is identical with the velocity potentiometer RATD1. RATD2 develops the integration signal fed to the velocity amplifier. The wiper of RATD2 is connected by an arm to UVTD8. (Refer to illustration #14-43.)

In the following explanation, an integration order signal through the integration and velocity systems will be traced. To simplify the explanation, it will be assumed that the velocity system is operating, but does not receive a velocity order signal. It will also be assumed that the launcher is following the director in right train when the error signal increases.

The right-train primary-error signal rotates the rotary piston cam counterclockwise and moves UVTD2 down. The downward movement of UVTD2 is transmitted to UVTD7 by the integration actuating lever. This movement of UVTD7 causes the integration control-pressure to decrease below 200 psi. This reduction in control pressure is transmitted, via UVTD20, to the large area side of UCTD8, causing UCTD8 to move up. (Refer to illustration #14-44 on the following page.)

NOTE: The integration piston continues to move up until UVTD2 returns to neutral or until UCTD8 reaches its limits of travel.

As the integration piston is being raised, it carries the wiper of RATD2 with it. The wiper movement originates an electrical signal which is transmitted to the velocity amplifier. This signal is of such a



☐ = PI PRESSURE (400 PSI)

☐ = CONTROL PRESSURE (0 TO 400 PSI)

☐ = TANK

VARIABLE HYDRAULIC AMPLIFIER PRESSURES

☐ = DECREASED HYDRAULIC AMPLIFIER PRESSURE

☐ = INCREASED HYDRAULIC AMPLIFIER PRESSURE

14-44. VELOCITY AND INTEGRATION SYSTEMS, RIGHT TRAIN OPERATION (same as 14-40) phase that the velocity electrohydraulic servo valve BCTD2 produces a control pressure below 200 psi. This control pressure causes the velocity piston to move up and to apply an increased right-train stroke to UVTD6.

The velocity-piston movement also positions the wiper of RATD1, to cancel the integration signal applied to the velocity amplifier.

The following is a summary of the operations of the primary, velocity, and integration systems when the launcher is following a dynamic signal. The following points should be kept in mind:

1. Primary control (no velocity or integration control) is used when the launcher is training or depressing to the load position or when it is synchronizing with a stationary signal (local or remote).

2. During operation in primary control only, the rotary piston must remain displaced in order to maintain a stroke on the A-end.

3. When the launcher is synchronizing with a moving local or remote signal, the primary and velocity signals are simultaneously applied to the stroke servo-system. The integration signal can not be applied until the launcher is synchronized with the local or remote signal.

4. The velocity stroke adds to primary stroke when the launcher is synchronizing with a director which is moving in the same direction as the launcher and subtracts from the primary stroke when the launcher and director are moving toward each other (during synchronization).

5. When the launcher is following a dynamic signal, the velocity input signal reduces the amount of rotary-piston displacement which was required to maintain the A-end stroke when only the primary system was controlling the power drive.

6. When an integration signal has been applied to UCTD8, this piston continues to apply its stroke until it (UCTD8) reaches its stroke limit or until the rotary piston returns to neutral. In order to remove the integration stroke of UCTD8, the rotary piston must be rotated in the opposite direction from neutral than it was rotated to apply the integration stroke. Therefore, when the launcher is following a dynamic signal, the rotary piston is considered to be continuously moving across its neutral position.

When the launcher is following a dynamic signal, the primary, velocity, and integration systems are all applying their signals to the stroke servo-system. At this time, the velocity piston is providing almost the entire amount of power-drive servo-signal required. (Normally, the part of the piston-stroke provided by the velocity system is larger than the part provided by the integration system.) If small persistent errors caused by roll, pitch, and unbalanced (loaded) guide arms didn't exist, theoretically the velocity signal would keep the launcher synchronized with the order signal; however, these errors are always present and must therefore continually be corrected by the primary and integration servo systems.

When the launcher is following a dynamic signal, the integration system input reduces the primary stroke (rotary-piston movement). This action of the integration system enables the primary system to react faster to an error signal than it would otherwise and thereby reduces the error between the order position and launcher position.

QUIZ SHEET:

1. The velocity tachometer-generator, located in the remote control computer, produces a voltage that indicates both the speed and direction of the order signal.

   True ______ or False ______.

2. Is the velocity control-pressure from BCTD2 above or below 200 psi when the director accelerates in right train?

   ________________________.

3. LCTD3 is deenergized when the launcher is

   a. Training to the load position.
   b. Following a local signal.
   c. Following a remote signal.
   d. Training toward a remote signal.

4. When the launcher is training left, the velocity neutralizing control-pressure is below 200 psi.

   True ______ or False ______.

5. Which one of the following valves cannot affect the position of UVTD20?

   a. UVTD10.
   b. UVTD7.
   c. UVTD3.
   d. UVTD2.

6. UVTD7 always remains on neutral when

   a. UCTD8 is on neutral.
   b. UCTD7 is on neutral.
   c. UCTD1 is on neutral.
   d. LCTD3 is deenergized.

7. RATD1 applies the integration signal to the velocity amplifier.

   True ______ or False ______.

8. When the launcher is training right to synchronize with a remote signal, the pressure in the chamber of UVTD7 is below 200 psi.

   True ______ or False ______.

9. When the launcher is training right to synchronize with a director which is moving left, the valves listed below are in the following positions (insert either below, above, or on):

   a. UVTD2 is ______ neutral.
   b. UVTD7 is ______ neutral.
   c. UVTD8 is ______ neutral.
   d. UVTD9 is ______ neutral.

TOPIC 6: LAUNCHER SYNCHRONIZING INDICATION SYSTEM

You Are Now Going To Learn:

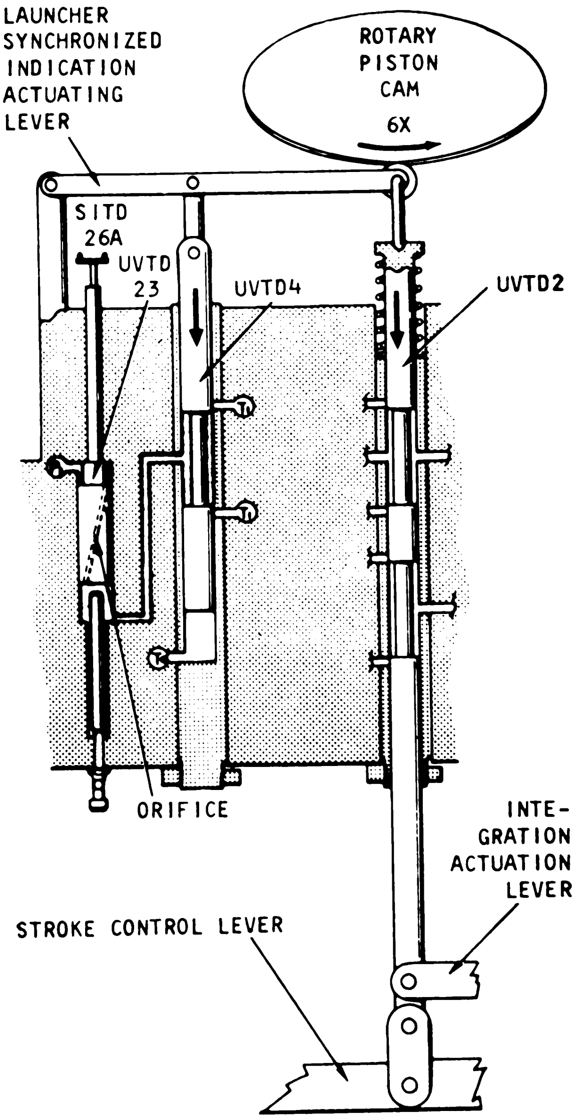
1. The operation of the launcher synchronizing indication system.

Discussion Points For This Topic Are:

1. Purpose of the launcher synchronizing indication system.
2. Launcher synchronizing actuating lever.
3. Launcher synchronizing indication valve UVTD4.
4. Launcher synchronizing indication piston UCTD23 and switch SITD26A.
5. Launcher synchronizing system operation.
6. Review and summary.

INFORMATION AND DISCUSSION:

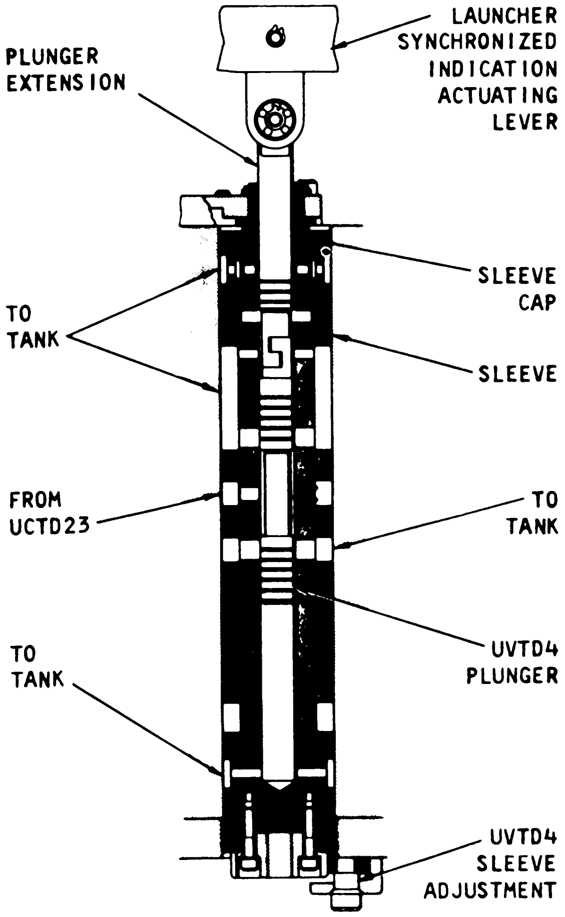
The launcher synchronizing indication system prevents the launcher from firing unless the launcher is synchronized with the director within approximately twenty-one minutes (21') and indicates (by means of lights) to weapons control and to the launcher captain when the launcher is synchronized. This system also provides a method of checking synchronization during tests. (Illustration #14-45 shows the system indicating that the launcher is synchronized.)


LAUNCHER SYNCHRONIZED INDICATION ACTUATING LEVER
ROTARY PISTON CAM
6X
SITD 26A
UVTD 23
UVTD4
UVTD2
ORIFICE
INTEGRATION ACTUATION LEVER
STROKE CONTROL LEVER

14-45. LAUNCHER SYNCHRONIZING INDICATION SYSTEM (B-END ERROR LESS THAN 21')

The launcher synchronizing actuating lever (shown in illustrations #14-45 and #14-46) transmits the primary stroke motion produced by the rotary-piston cam to the synchronizing indication valve UVTD4.

UVTD4, the launcher synchronizing indication valve, controls the operation of the synchronizing piston UCTD23. When the error between the launcher and the order signal is less than 21', UVTD4 blocks the port from UCTD23; when the error exceeds 21', UVTD4 connects UCTD23 to tank.



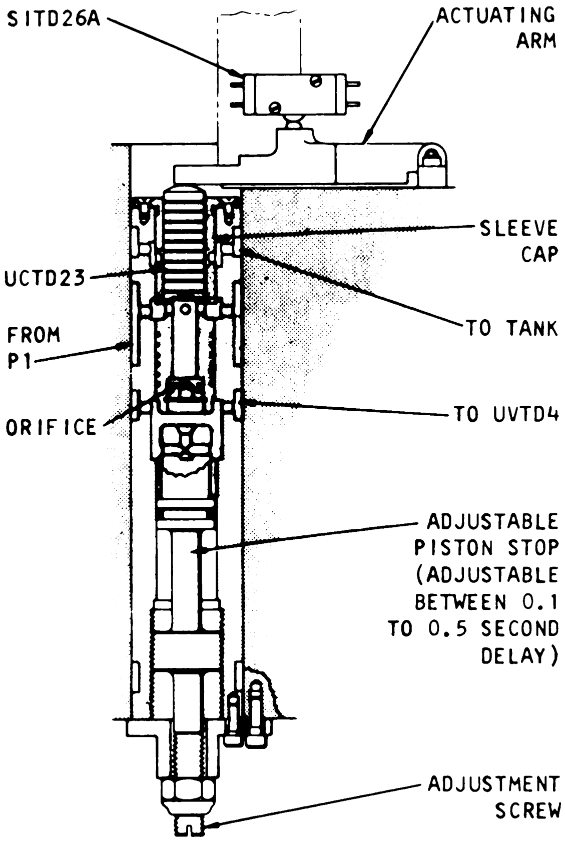
14-46. UVTD4

UCTD23, the launcher synchronizing indication piston, actuates switch SITD26A to indicate whether the launcher is synchronized or not. Whenever the power drive is running, P1 servo pressure (400 psi) is ported to the small area end (top) of the piston and then is transmitted through a drilled passage and orifice to the large area end (bottom) of the piston.

When the pressure on the large area end of the piston is blocked by UVTD4 (within 21' of synchronization), the piston is up, contacting the actuating arm of SITD26A and closing the switch-contacts. When the volume on the large area end of the piston is ported to tank through UVTD4 (more than 21' from synchronization), UCTD23 moves down.

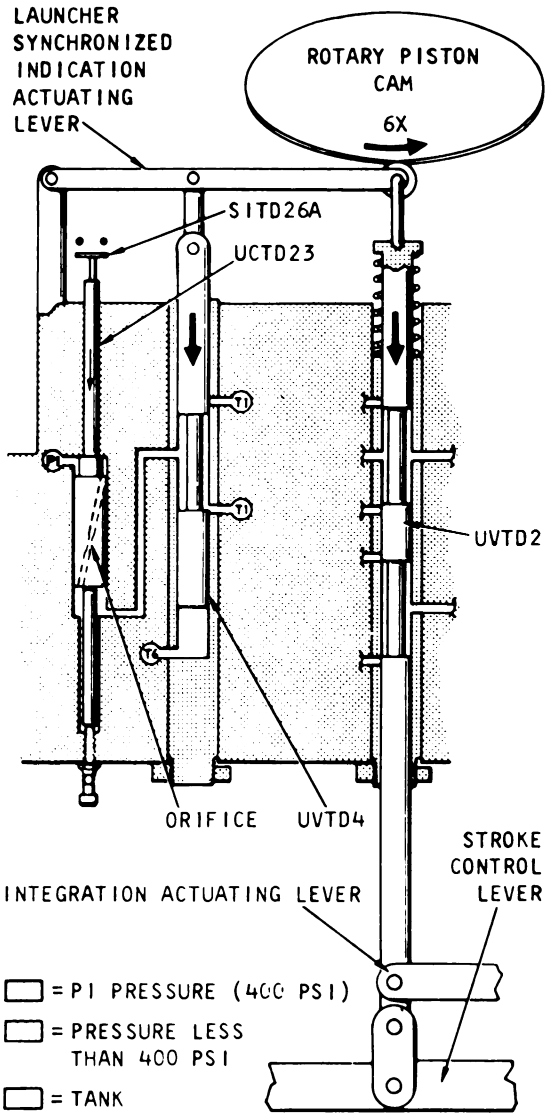
Illustration #14-47 on the following page shows one adjustable piston stop at the large area end of UCTD-23. This stop is adjusted so that the piston requires 1/4 second (time) to complete its movement; therefore, during launcher synchronization, the error is actually less than 21' before the firing circuit closes.

In the following brief description of the launcher synchronizing indication system it will be assumed that the launcher is synchronized with the director in right train and UCTD23 is up, closing the contacts of SITD26A. (Refer to illustration #14-45.) At this point, the launcher accelerates until the error exceeds



14-47. UCTD23

21'. The rotary piston, through linkage, moves UVTD4 down, opening its chamber to tank. (Refer to illustration #14-48.) Since the fluid can pass faster through UVTD4 than it can be replenished through the orifice in UCTD23, the pressure on the large area end of UCTD23 is caused to drop. This pressure drop moves UCTD23 down and opens the contacts of switch SITD26A, causing the system to indicate that the launcher is no longer synchronized with the director. (Refer to illustration #14-48.)


LAUNCHER SYNCHRONIZED INDICATION ACTUATING LEVER
ROTARY PISTON CAM
6X
SITD26A
UCTD23
T1
T1
T2
UVTD2
ORIFICE
UVTD4
STROKE CONTROL LEVER
INTEGRATION ACTUATING LEVER
▭ = P1 PRESSURE (400 PSI)
▭ = PRESSURE LESS THAN 400 PSI
▭ = TANK

14-48. LAUNCHER SYNCHRONIZING INDICATION SYSTEM (B-END ERROR EXCEEDS 21')

TOPIC 7: LIMIT-STOP AND AUTOMATIC TRACKING CUTOUT SYSTEMS

You Are Now Going To Learn:

1. Limit-stop system operation.
2. Automatic tracking cutout system operation.

Discussion Points For This Topic Are:

1. Purpose of limit-stop system.
2. Limit-stop assembly.
3. Limit-stop valve UVED12 and limiting piston UCED12.
4. Limit-stop brake.
5. Limit-stop rack.
6. Limit-stop operation.
7. Purpose of automatic tracking cutout system.
8. Nonpointing zones defined.
9. Nonpointing zone solenoids, valves, and pistons.
10. Automatic tracking cutout system operation.
11. **Instrumentation.**
12. **Review and summary.**

INFORMATION AND DISCUSSION:

In this topic, the elevation limit-stop and automatic tracking cutout systems will be described. Any differences between the elevation and train systems will be pointed out as the components of these systems are explained.

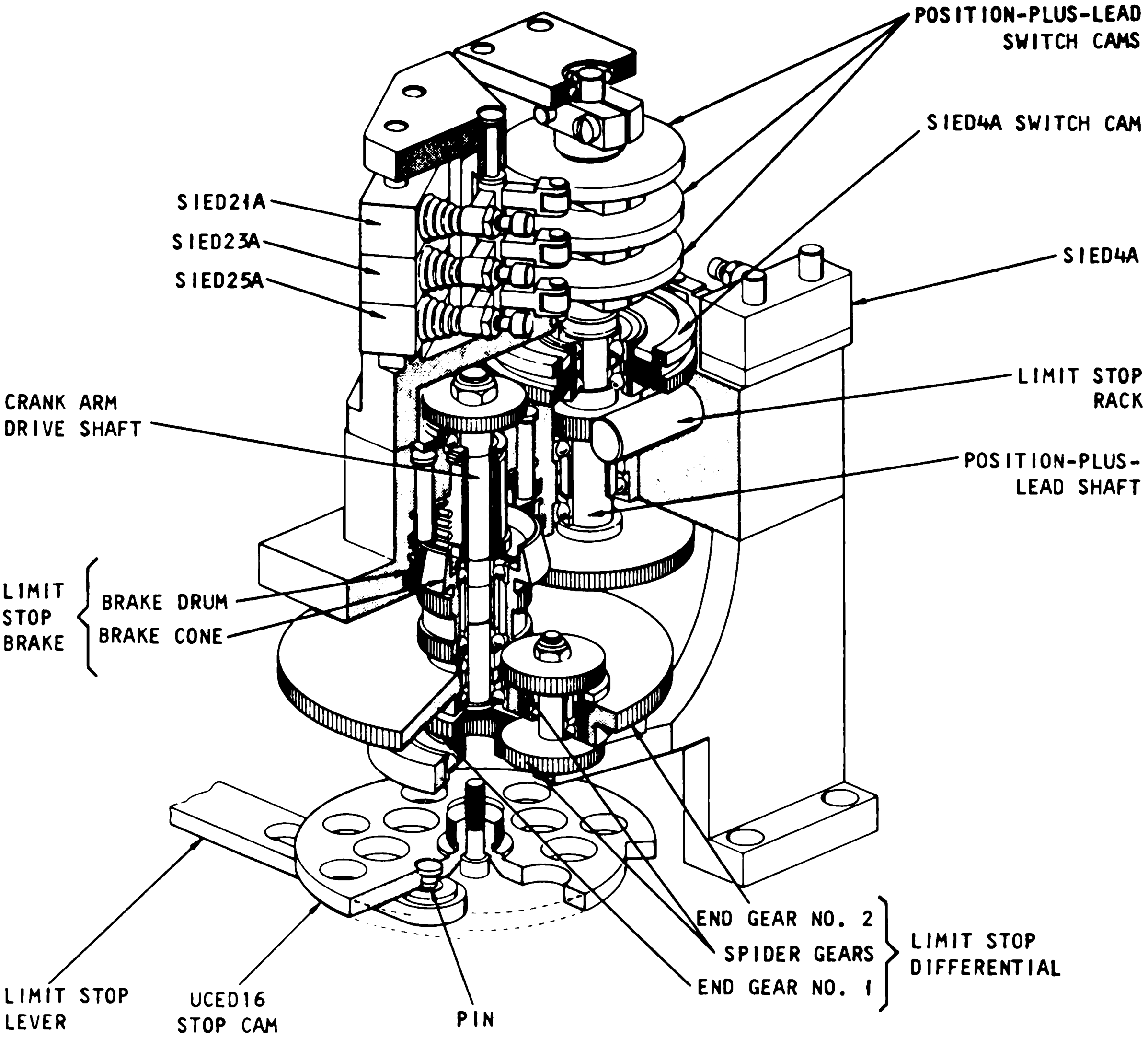
The purpose of the elevation limit-stop system is to automatically stop the power drive by returning the A-end to neutral whenever the launcher reaches the elevation or depression limits or when a power failure occurs. (The train limit-stop system has no fixed limit stops, but is capable of returning the A-end to neutral when a power failure occurs.)

The stop order for elevation is originated either by elevation and depression fixed stops or by a limit-stop brake.

NOTE: The limit-stop systems are also used by the automatic tracking cutout system for stopping the power drives.

The elevation limit-stop system consists of the following basic components:

1. Limit-stop cam.
2. Limit-stop lever.
3. Limit-stop valve UVED12 and piston UCED12.
4. UCED16 stop-cam.



14-49. ELEVATION LIMIT-STOP ASSEMBLY

5. Limit-stop differential.

6. Limit-stop brake.

7. Limit-stop rack.

8. Switches, switch cams, and related gearing.

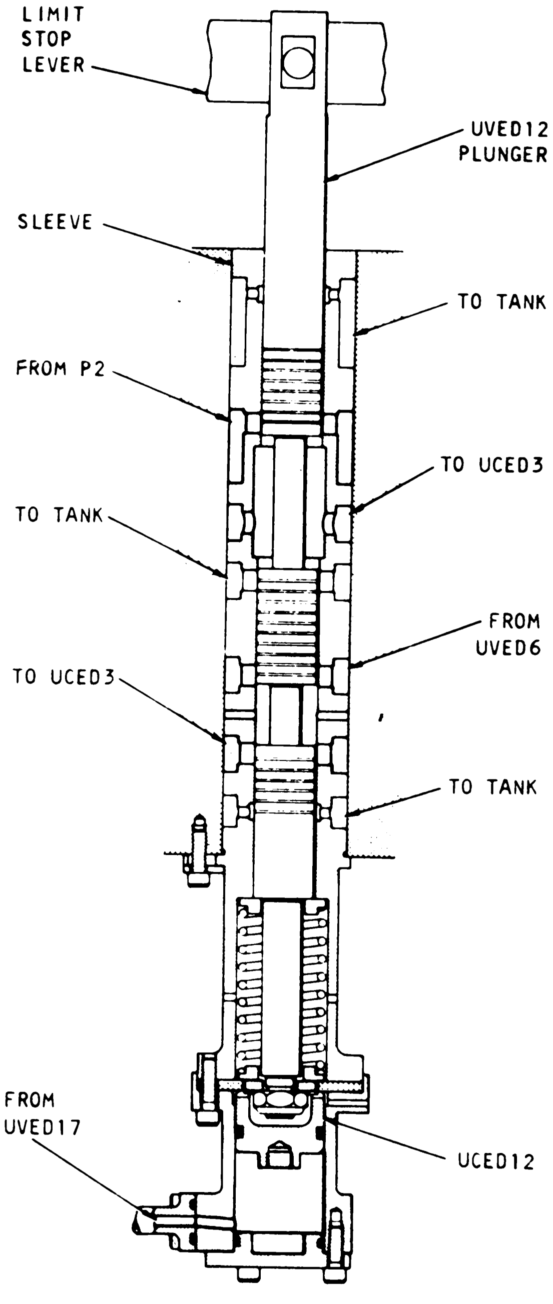
The elevation limit-stop system components (except the limit-stop cam and valve UVED12) are shown in illustration #14-49 above.

The elevation limit-stop cam is positioned by A-end response and applies the A-end tilt input (also referred to as lead) to the limit-stop lever. When the limit-stop system receives a stop order, the cam controls the deceleration rate of the launcher as the stop order is being carried out. (The construction and arrangement of the cam were covered in Topic 2 of this section and were shown in illustration #14-14.)

The limit-stop lever transmits the limit-stop cam movement to UCED16 stop-cam and thus supplies the differential with a lead input. One end of the lever is connected to the limit-stop cam, while the other end is connected to UCED16 stop-cam. (Refer to illustration #14-49.) The center of the lever is connected to UVED12.

During normal operation, when the limit-stop cam movement is transmitted to UCED16 stop-cam, the lever is pivoted on UVED12. During limit-stop operation, the limit-stop cam also transmits motion to the limit-stop lever; therefore during limit-stop operation, the lever is receiving two inputs, and UVED12 is forced to move from its spring-loaded neutral position.

UVED12, the limit-stop valve, is a spring-centered, two-chamber valve which returns the A-end to neutral during limit-stop operation, by controlling the pressure to the large area stroking piston UCED3. (Refer to illustration #14-50.) When UVED12 is on neutral, its lower chamber acts simply as a port for the control pressure between UCED3 and UVED6; however, when UVED12 is moved away from neutral in either direction, its lower chamber blocks the hydraulic line between UVED6 and UCED3. When the limit-stop system is activated, the upper chamber of UVED12 develops the pressure necessary to return UCED3 to neutral. When UVED12 is on neu-



14-50. UVED12 AND UCED12

tral, 200 psi develops in its upper chamber.

UCED12, the elevation limit-stop limiting piston, limits the outward movement of UVED12 to .028". (Illustration #14-50 shows outward, or downward, movement of UVED12.) During normal limit-stop operation, UVED12 moves only approximately .013"; therefore, the piston has no effect in normal limit-stop operation. However, when the automatic tracking cutout system is in operation, the piston may displace the plunger more than .028". This extra outward movement may prematurely close the nonpointing zone switches and cause the launcher to enter a nonpointing zone. Since the automatic tracking cutout system transmits only elevation orders, only one piston (UCED12) is needed. (The train limit-stop valve UVTD12 has no piston.)

During normal operation, UCED-16 stop-cam (shown in illustration #14-49) transmits the A-end tilt input (lead) from the limit-stop lever to the differential. During limit-stop operation, its function reverses: The stop cam now transmits stop orders from the differential to the lever.

During power operation, the movement of the UCED16 stop-cam is limited by the hydraulically actuated piston UCED16 to 50° of movement. When the power is off, the piston (shown in illustration #14-51) is retracted by a spring.

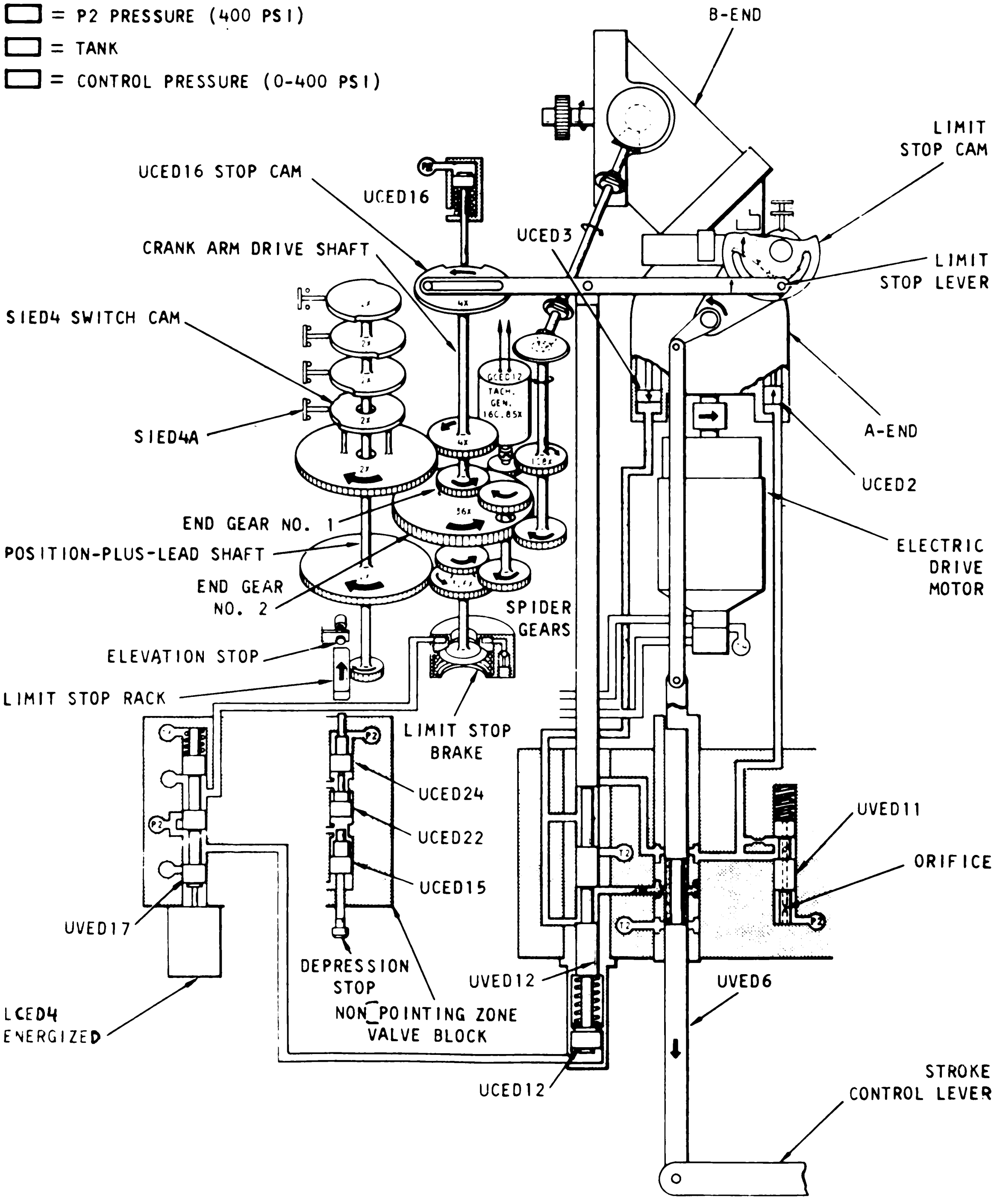
NOTE: On elevation receiver-regulators serial #10 and above, the piston has been omitted and a crank arm (similar to the one used in train) has been substituted for the UCED16 stop-cam. (The train crank-arm was decribed in Topic 2 of this section and was shown in illustration #14-11.)

The elevation limit-stop differential combines B-end response (position) with A-end response (lead) and transmits the resulting output through the limit-stop brake to the position-plus-lead shaft and to the limit-stop rack. If the brake sets or the limit-stop rack is stopped, the differential output is fed back through UCED16 stop-cam to the limit-stop lever.

NOTE: Shown in illustration #14-49 is the spur-type differential used in the limit-stop system. In order to understand how the differential functions, compare illustration #14-49 with illustration #14-51 (schematic) which shows the differential rotated 180°.

Illustration #14-51 on the following page shows A-end response (lead) being applied to end-gear #1, and B-end response (position) applied to end-gear #2. The two inputs are combined to drive the spider gears. The spider gears, in turn, position the limit-stop brake, the position-plus-lead shaft, and the limit-stop rack.

When the limit-stop brake sets



14-51. LIMIT-STOP SYSTEM DURING NORMAL OPERATION

LIMIT-STOP AND AUTOMATIC TRACKING CUTOUT SYSTEMS

or the limit-stop rack is stopped, the gear which meshes with the upper spider gear (shown in illustration #14-51 as the lower spider gear) also stops. B-end response, however, continues to drive end-gear #2; therefore, the spider gear is forced to walk around the stopped gear. This action of the spider gear causes end-gear #1 to reverse its normal rotation direction. This reverse motion of end-gear #1 is transmitted via UCED16 stop-cam and stroke-control lever to UVED12, and UVED12 is forced to move in the required direction to remove the A-end tilt.

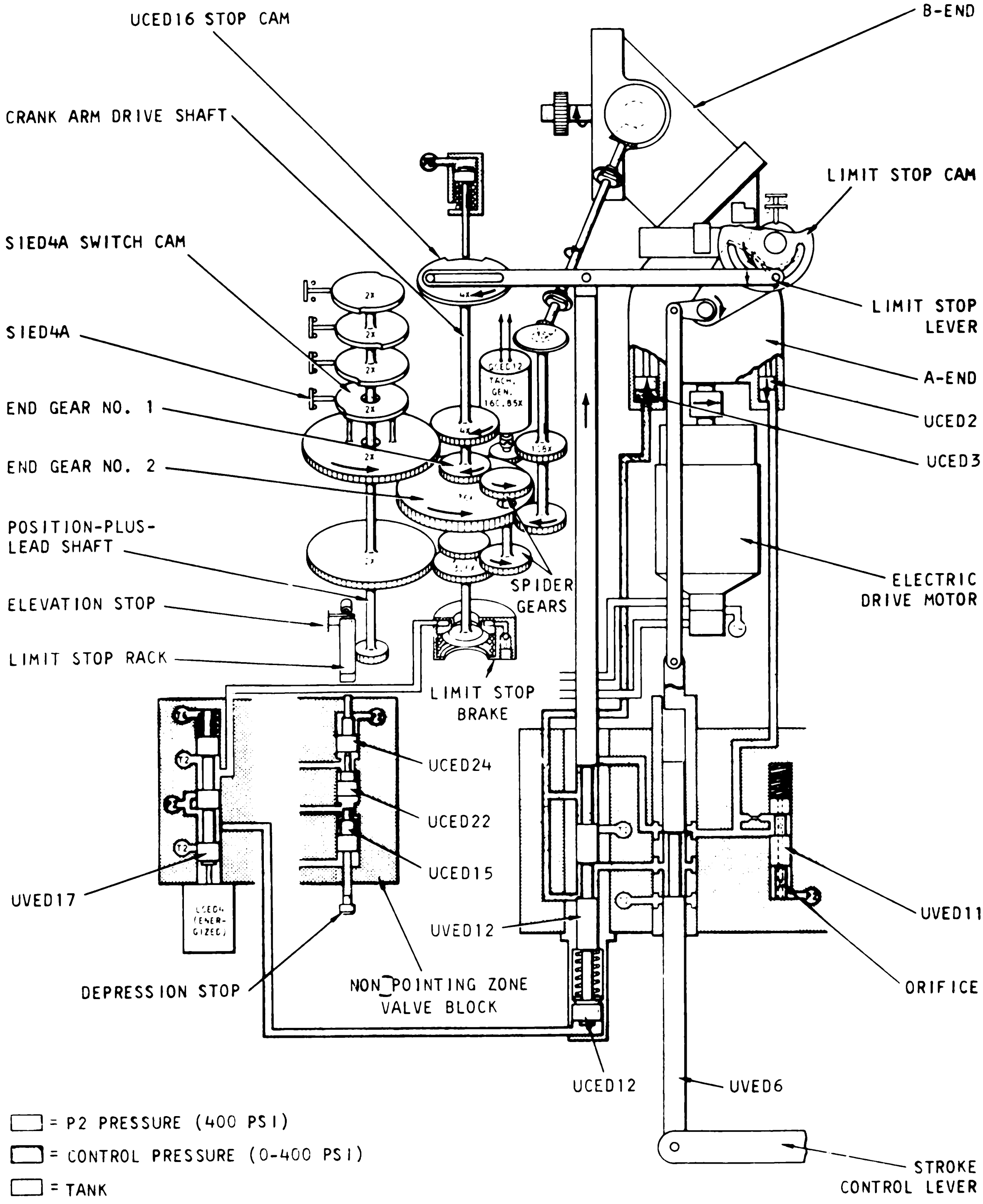
The limit-stop brake is hydraulically set and spring-released. The hydraulic fluid (servo at 400 psi) is controlled by solenoid LCED4-operated control-valve UVED17. (Refer to illustration #14-51.) UVED17 is located in the nonpointing-zone valve-block. When the solenoid is energized (refer to illustration #14-51), UVED17 connects the limit-stop brake to tank and UCED12 to P2 (400 psi). When, due to a power failure, the solenoid becomes deenergized, UVED17 ports servo pressure to the brake, causing it to set.

The limit-stop rack (shown in illustration #14-51) is driven by the position-plus-lead shaft and stops the normal output of the differential whenever the launcher reaches the minimum limits in elevation or depression. The rack also transmits the output of the automatic tracking cutout system to the limit-stop system. (Instead of the limit-stop rack, the train power drive has a cam which functions only during automatic tracking cutout system operation.)

In the following description of the operational cycle of the limit-stop system it will be assumed that the launcher is elevating (as shown in illustration #14-51) when the limit-stop rack contacts the upper fixed limit. (Refer to illustration #14-52 on the following page.) All movements of valves and linkage will be described schematically.

When an elevation signal is received, the plunger of UVED6 moves down, causing the limit-stop cam to rotate clockwise. This movement of the cam forces the right end of the limit-stop lever to move up. The limit-stop lever is free to pivot on UVED12 and forces UCED16 stop-cam to rotate counterclockwise. The movement of the UCED16 stop-cam is transmitted to end-gear #1 of the differential. The counterclockwise rotation of end-gear #1 is then transmitted by the spider gears of the differential to the limit-stop rack, causing the rack to move toward the elevation fixed stop. This limit-stop rack movement is called lead and is directly proportional to the amount of A-end tilt applied.

When A-end tilt is applied, the launcher starts elevating, and the B-end response input to end-gear #2 of the differential causes end-gear #2 to rotate counterclockwise.



14-52. LIMIT-STOP SYSTEM ACTING AS SERVO TO STOP LAUNCHER

The counterclockwise movement of end-gear #2 is transmitted by the spider gears to the limit-stop rack, causing the rack to move toward the elevation fixed stop. The movement of the limit-stop rack which is caused by B-end response is proportional to the distance the launcher elevates and is called position.

When the launcher reaches the upper limit of elevation (shown in illustration #14-52), the limit-stop rack contacts the elevation fixed stop and prevents further movements of the gear which meshes with the lower spider gear.

B-end response, however, is still rotating end-gear #2, and the movement of end-gear #2 forces the lower spider gear to walk around the gear which meshes with the lower spider gear, thereby reversing the direction of the spider gear and forcing end-gear #1 to rotate clockwise. (Refer to illustration #14-52.)

NOTE: When A-end response was received, end-gear #1 rotated counterclockwise and was driving the spider.

The clockwise motion of end-gear #1 is transmitted by UCED16 stop-cam to the left end of the limit-stop lever, causing the lever to move up. The right end of the limit-stop lever is prevented from moving by the slot in the limit-stop cam; therefore, UVED12 is forced up. (Refer to illustration #14-52.) The upward movement of UVED12 blocks the hydraulic passage between UVED6 and the large area stroking piston UCED3 and connects the upper chamber of UVED12 (pressure exceeding 200 psi) to UCED3. This action of UVED12 causes the A-end stroke to be removed.

NOTE: A transition period exists before UVED12 can take over control of the A-end from UVED6; UVED12 moves approximately .013" before it assumes complete control of the launcher. In order to displace UVED12 .013", the launcher must move approximately 35' in elevation.

As the stroke is being removed, the right end of the limit-stop lever moves down. The left end of the limit-stop lever, however, continues to move up, leading the right end until the launcher stops elevating. The amount which the left end of the limit-stop lever leads the right end is determined by the contour of the limit-stop cam. Due to the special contour characteristics of the limit-stop cam, a constant launcher deceleration rate is achieved.

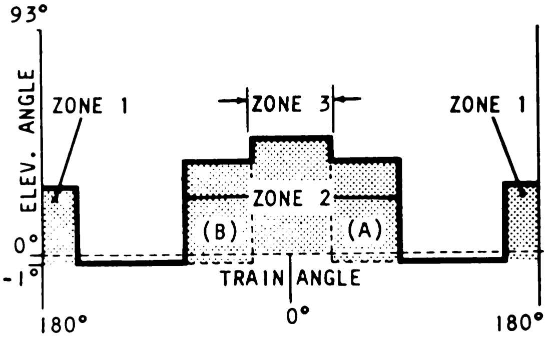
When the limit-stop action is completed, the limit-stop cam is on neutral, but UCED16 stop-cam and UVED12 are above their normal neutral position. This off-neutral position (.013") of UVED12 prevents UVED6 from regaining control and from attempting to drive the launcher further into the stop. Thus, UVED12 retains control of the A-end until the power drive receives a depression order.

The automatic tracking cutout system prevents a weapon on a launcher guide-arm from striking or pointing into any part of the ship's superstructure. These areas, as pointed out previously, are called nonpointing zones.

NOTE: Many publications associated with missile launching systems refer to nonpointing zones as "interference" or "blind" zones. Only recently BuWeps has standardized the nomenclature of these zones.

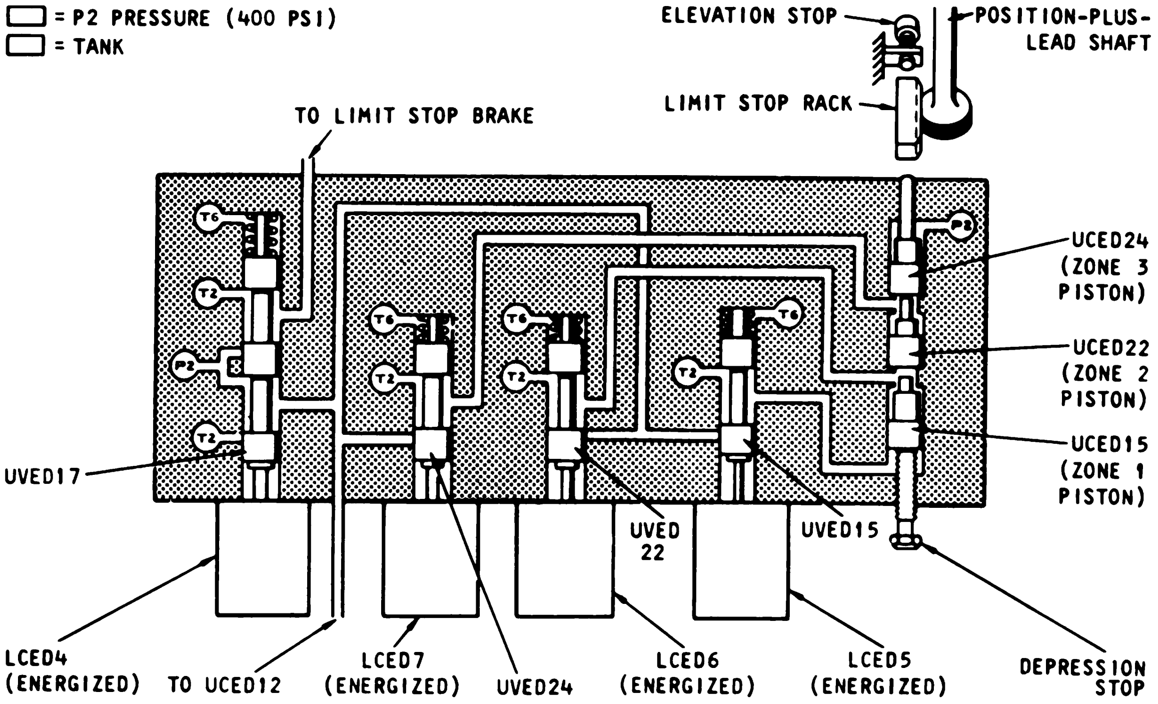
Typical nonpointing zones for an aft-mounted launcher are shown in illustration #14-53. Zone #3 is the highest; it represents the ship's mast, bridge, and stacks. Zone #2 includes the superstructure directly behind the launcher (forward on ship). On the majority of missile launching systems which are equipped with Mk 5 launchers, zone #2 represents the missile house. Zone #1 is the lower zone which comprises certain structures on the aft end of the ship.

The elevation automatic tracking cutout system operates by changing the position of the launcher depression limits whenever a loaded launcher guide-arm enters a nonpointing zone. Nonpointing-zone pistons UCED15, UCED22, and UCED24 (shown in illustration #14-54 on the following page) utilize the limit-stop rack to prevent the launcher from depressing into a nonpointing zone or to cause the launcher to elevate over a nonpointing zone. The pistons are hydraulically controlled by solenoid-operated valves. When the solenoids are energized, the valves are extended into the valve block and the hydraulic fluid is prevented by the lower lands of the valves from reaching the large area ends of the pistons. The P2 pressure ported to the small area end of UCED24 holds all three pistons against the depression stop. When this condition exists, the three pistons are acting merely as an extension for the fixed depression stop. Note that if the limit-stop brake-solenoid LCED4 is deenergized (as shown in illustration #14-54), the flow of servo fluid to the nonpointing zone valves is blocked by the center land of UVED17, thus preventing nonpointing-zone operation when the limit-stop brake is set.



14-53. TYPICAL NONPOINTING ZONES (AFT MOUNTED LAUNCHER)

The nonpointing-zone solenoids



14-54. ELEVATION NONPOINTING ZONE VALVE-BLOCK COMPONENTS

for elevation are controlled by position and position-plus-lead cams in the train receiver-regulator. If the loaded launcher is training in a clear area (no nonpointing zones), the elevation nonpointing-zone solenoids remain energized; however, when the launcher, while training, approaches a nonpointing zone, the solenoid for that zone in the elevation receiver-regulator deenergizes.

Illustration #14-55 on the following page shows LCED7 (the solenoid for nonpointing zone #3) deenergized, and servo pressure ported through the center of UVED24 to the large area end of UCED24, causing the piston to extend. If the launcher is at this time elevated above the nonpointing zone, the extending piston does not contact the limit-stop rack and the elevation power-drive continues operating normally. However, if the following two conditions exist, the elevation power-drive does not function normally:

1. If the elevation power-drive depresses the launcher so that a loaded guide arm approaches the top of the nonpointing zone, the limit-stop rack contacts the extended piston and stops the elevation power-drive. (Refer to illustration #14-55 on the following page.) As soon as the launcher trains clear of the nonpointing zone, LCED7 energizes and the elevation power-drive can continue to depress the launcher.

2. If the launcher is depressed below the nonpointing zone when the nonpointing-zone piston extends, the limit-stop rack is forced away from the depression stop by action of the piston and, through the action of the limit-stop system (differential, limit-stop lever, and UVED12), causes the launcher to elevate over the nonpointing zone.

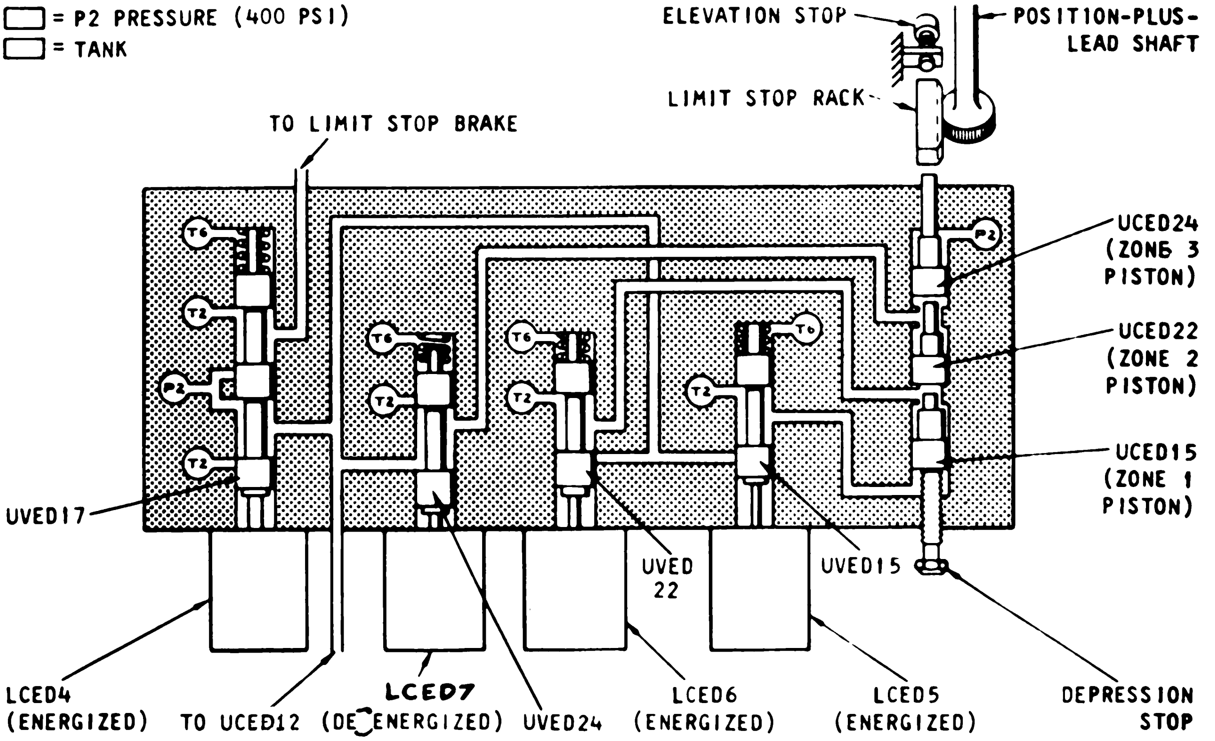
The train automatic tracking cutout system prevents a loaded launcher guide-arm from training into a nonpointing zone. This system (shown in illustration #14-56 on the following page) consists of the following components:

1. Nonpointing-zone cam.

2. Two nonpointing-zone pistons.

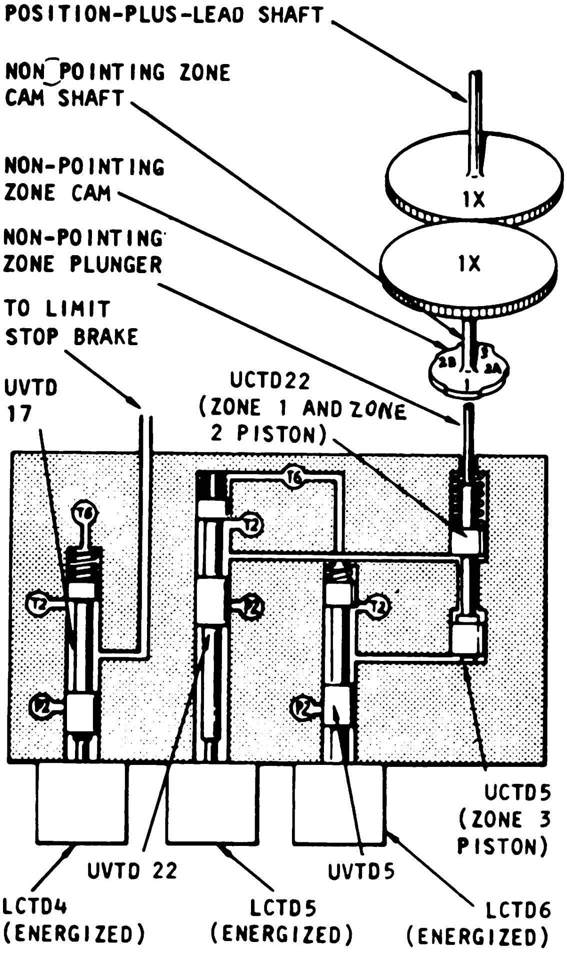
3. Two nonpointing-zone solenoid-operated control valves.

The nonpointing-zone cam is positioned by the limit-stop position-plus-lead shaft. For each nonpointing zone, lugs are cut into the cam. When a cam lug contacts one of the nonpointing-zone piston-plungers, the limit-stop spider is prevented from driving the position-plus-lead shaft; therefore, the differential output is transmitted through the limit-stop lever to UVTD12, causing



14-55. ACTIVATING NONPOINTING ZONE #3

LIMIT-STOP AND AUTOMATIC TRACKING CUTOUT SYSTEMS



14-56 TRAIN NONPOINTING ZONE VALVE-BLOCK COMPONENTS

the train power-drive to stop.

The two nonpointing-zone pistons UCTD22 and UCTD5 are used in the train automatic tracking cutout system: UCTD22 is used to stop the train power-drive when the launcher is approaching nonpointing zone #1 or #2, and UCTD5 is used to prevent the launcher from training into zone #3. UCTD22 is controlled by solenoid LCTD5 -operated valve UVTD22; UCTD5 is controlled by solenoid LCTD6 -operated valve UVTD5. Both pistons are controlled in the same way as the elevation pistons; however, the train limit-stop brake-solenoid (LCTD4) valve UVTD17 does not control P2 (servo pressure) to the automatic tracking cutout system solenoid-operated control-valves as the elevation-brake solenoid-valve does.

Solenoids LCTD5 and LCTD6 are controlled by cam-operated switches in the elevation receiver-regulator. LCTD5 is deenergized when the launcher is depressed by the elevation power-drive below nonpointing zones #1 and #2, and KCTD6 is deenergized when the launcher is depressed below zone #3.

In the following description of automatic tracking cutout system operation it will be assumed that a loaded launcher is training right into nonpointing zone #3 and that the elevation power-drive is depressing the launcher below zone #3.

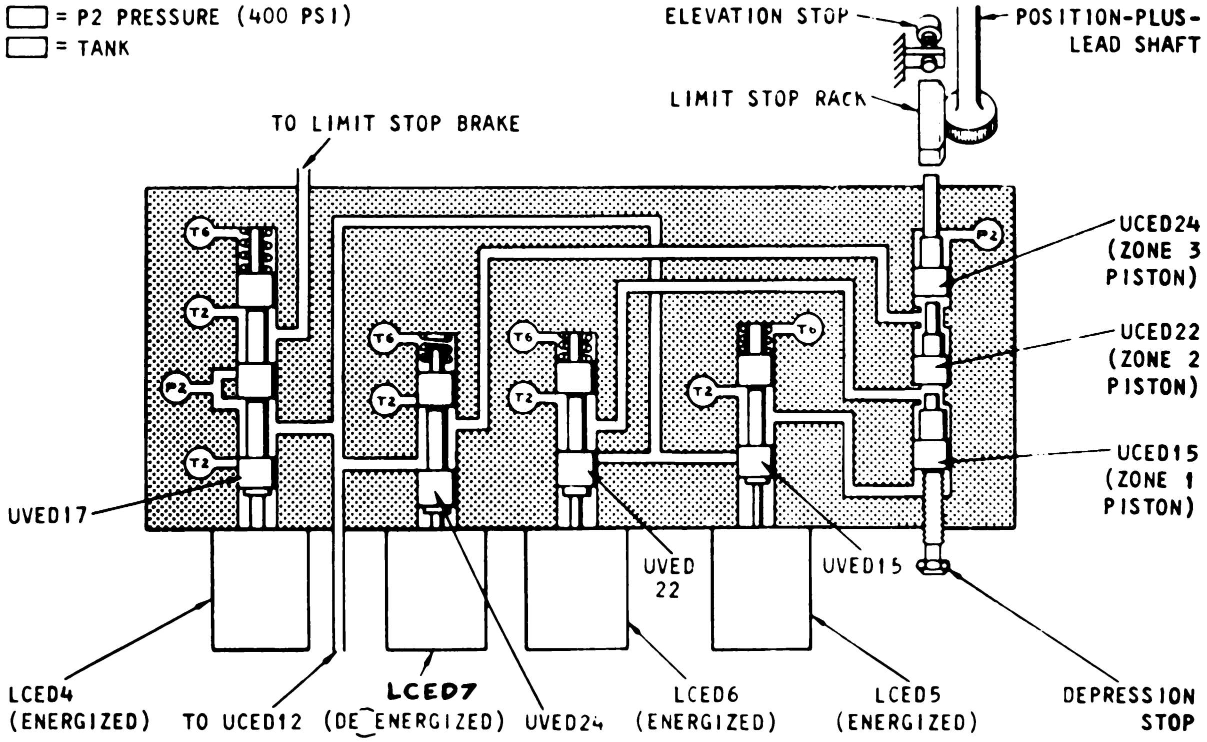
As the launcher approaches nonpointing zone #3, the position-plus-lead switch for zone #3 in the train receiver-regulator opens, causing solenoid LCED7 in the elevation receiver-regulator to deenergize. (Refer to illustration #14-57 on the following page.) UVED24 now connects P2 servo pressure to the large area end of UCED24, causing UCED24 to extend.

With the launcher below zone #3,

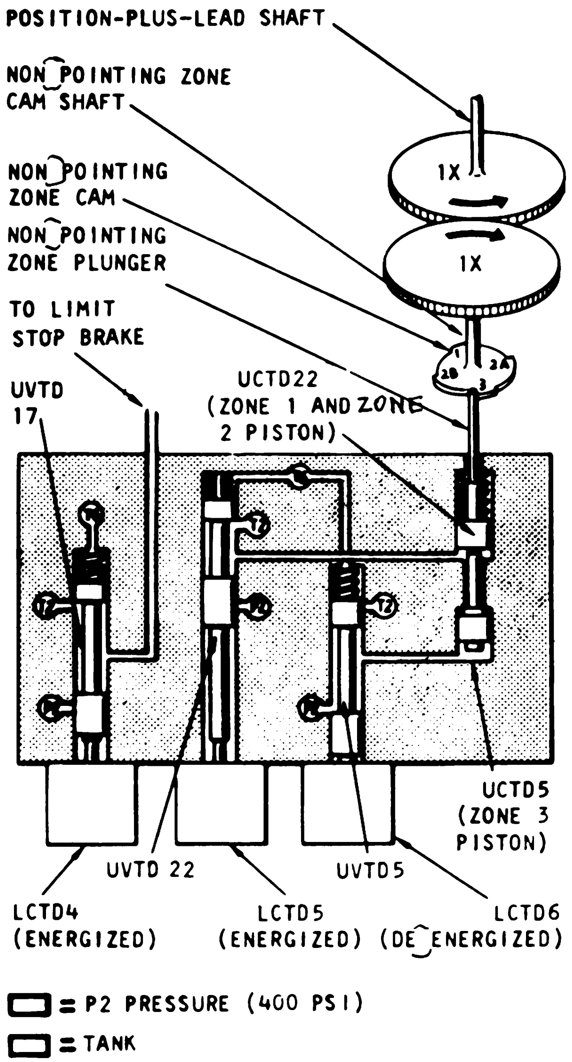
the limit-stop rack (shown in illustration #14-57) would have been moved up when piston UCED24 was extended. The upward movement of the limit-stop rack is transmitted by the limit-stop system to UVED12, and the A-end is now controlled by UVED12, causing the elevation power-drive to elevate the launcher over nonpointing zone #3.

As the launcher elevates, the train power-drive continues to move the launcher toward nonpointing zone #3. If the elevation power-drive cannot elevate the launcher over zone #3 before the train nonpointing-zone cam contacts the nonpointing-zone plunger (as shown in illustration #14-58), the train power-drive is immediately stopped and remains stopped until LCTD6 energizes.

NOTE: If the elevation power-drive is able to elevate the launcher clear of zone #3 before the launcher trains into zone #3, the train power-drive does not stop the launcher, because the position-switch in the elevation receiver-regulator closes, causing LCTD6 in the train receiver-regulator to energize. With LCTD6 energized, the nonpointing-zone piston UCTD5 and the nonpointing-zone plunger are retracted clear of the nonpointing-zone cam.



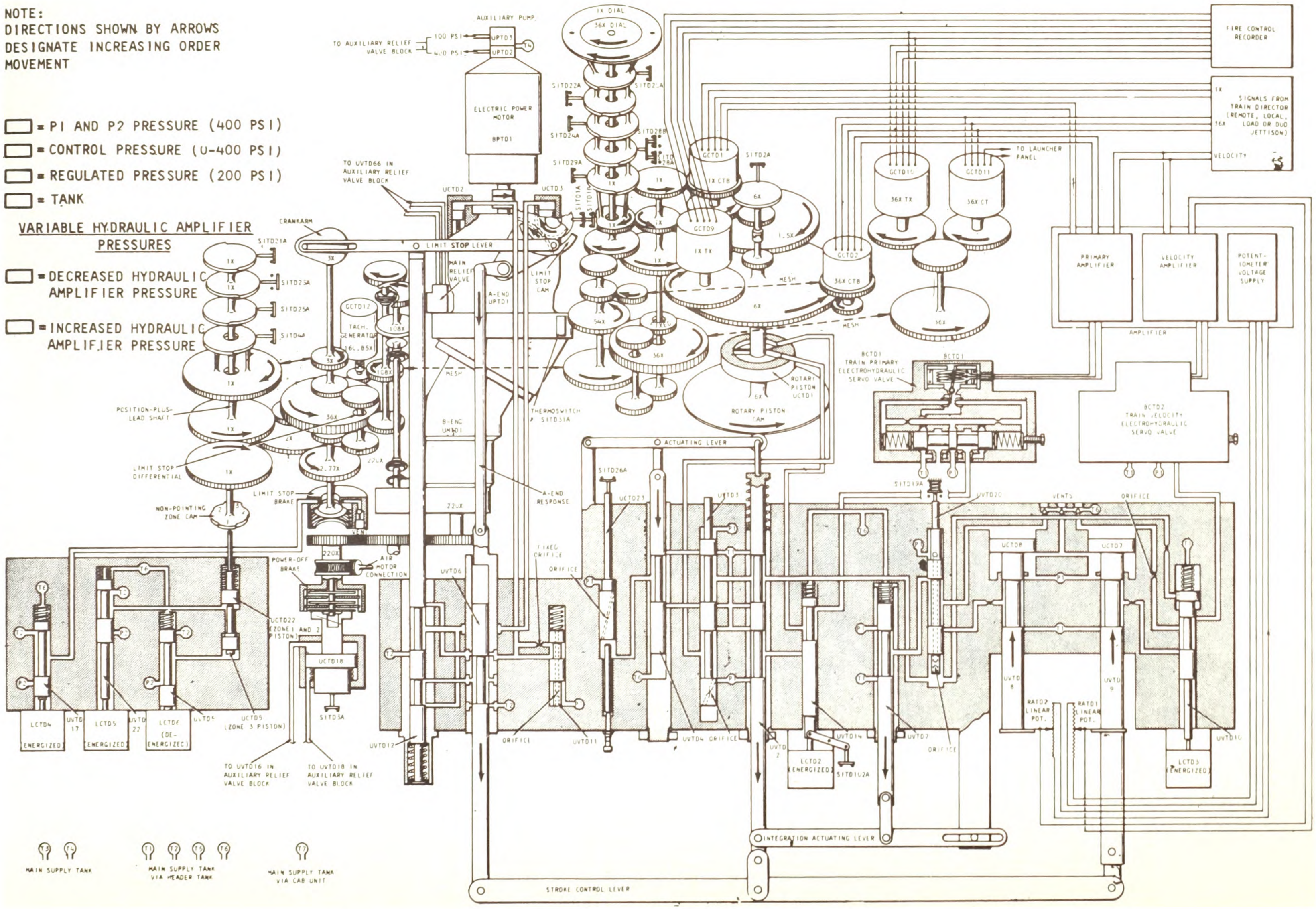
14-57. ACTIVATING NONPOINTING ZONE #3
(same as 14-55)



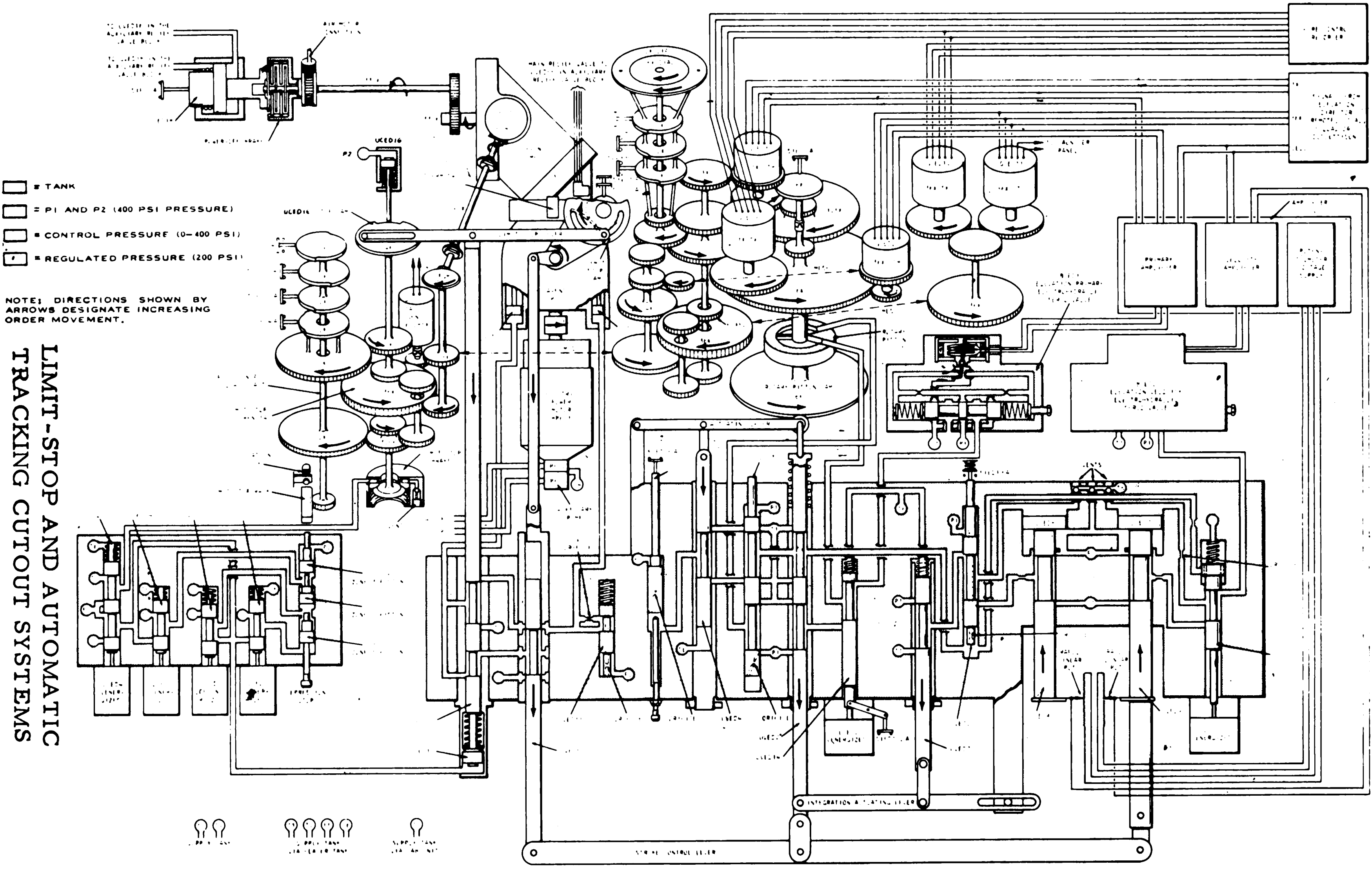
14-58. SETTING THE TRAIN LIMITS OF NONPOINTING ZONE #3

The elevation power-drive keeps the launcher elevated above nonpointing zone #3 until a cam-operated switch in the train receiver-regulator closes, indicating that the launcher is clear of nonpointing zone #3. When this position-switch closes, LCED7 energizes, releasing the elevation limit-stop rack and allowing the elevation power-drive to depress the launcher to the order position.

This completes the description of the receiver-regulators Mk 45 and Mk 37. (Illustrations #14-59 and #14-60 on the following pages show complete schematics of the train and elevation receiver-regulators.)



14-59. TRAIN RECEIVER-REGULATOR SCHEMATIC


= TANK
= P1 AND P2 (400 PSI PRESSURE)
= CONTROL PRESSURE (0–400 PSI)
= REGULATED PRESSURE (200 PSI)
LIMIT-STOP AND AUTOMATIC TRACKING CUTOUT SYSTEMS
P2
PRIMARY AMPLIFIER
VENTS
INTEGRATION & FLOATING LEVER

NOTE: DIRECTIONS SHOWN BY ARROWS DESIGNATE INCREASING ORDER MOVEMENT.

14-60. ELEVATION RECEIVER-REGULATOR SCHEMATIC

QUIZ SHEET:

1. The train limit-stop brake is set when

   a. The launcher contacts a positive stop.
   b. The launcher is entering a nonpointing zone.
   c. A power failure occurs.
   d. The guide arm is being loaded.

2. During elevation limit-stop operation, the limit-stop lever pivots on UVED12.

   True ______ or False ______.

3. End-gear #2 of the differential is driven during limit-stop operation by

   a. B-end response.
   b. A-end response.
   c. Spider.
   d. Limit-stop rack.

4. The limit-stop brake is released by hydraulic pressure.

   True ______ or False ______.

5. During limit-stop operation, after the A-end has been returned to neutral, the limit-stop valve must remain off its normal neutral position to keep the A-end on neutral.

   True ______ or False ______.

6. During limit-stop operation, the lower chamber (as shown schematically) of UVED12

   a. Connects UVED12 to UCED3.
   b. Connects UVED6 to UCED3.
   c. Blocks the port between UVED12 and UCED3.
   d. Blocks the port between UVED6 and UCED3.

7. During automatic tracking cutout operation, solenoids LCED5, LCED6, and LCED7 are controlled by cam-operated switches in the elevation receiver-regulator.

   True ______ or False ______.

8. If the elevation power-drive depresses the launcher below a nonpointing zone when the launcher in train approaches that zone, the elevation automatic tracking cutout system performs one of the following actions:

   a. Neutralizes the elevation power drive.
   b. Sets the train limit-stop brake.
   c. Causes the launcher to elevate.
   d. Causes the launcher to depress.

9. LCED5 deenergizes when the

   a. Elevation power drive depresses the launcher below nonpointing zone #3.
   b. Train power drive causes the launcher to approach nonpointing zone #3.
   c. Elevation power drive depresses the launcher below nonpointing zone #1.
   d. Train power drive causes the launcher to approach nonpointing zone #1.

10. LCTD4 must be energized before P2 servo pressure (400 psi) can be ported to the automatic tracking cutout system.

    True ______ or False ______.

TOPIC 8: OTHER RECEIVER-REGULATOR MODELS

You Are Now Going To Learn:

1. Characteristics of other receiver-regulator models.

Discussion Points For This Topic Are:

1. Early models of launcher receiver-regulators.
2. Launcher receiver-regulator Mk 116.
3. 5"38-caliber twin gun-mount indicator receiver-regulator.
4. Rocket launcher Mk 108, B-end synchro-unit and stroke-control unit.
5. 3"50-caliber rapid fire (RF) gun-mount receiver-regulator.
6. Summary and review.
7. Section review.
8. Written test.

INFORMATION AND DISCUSSION:

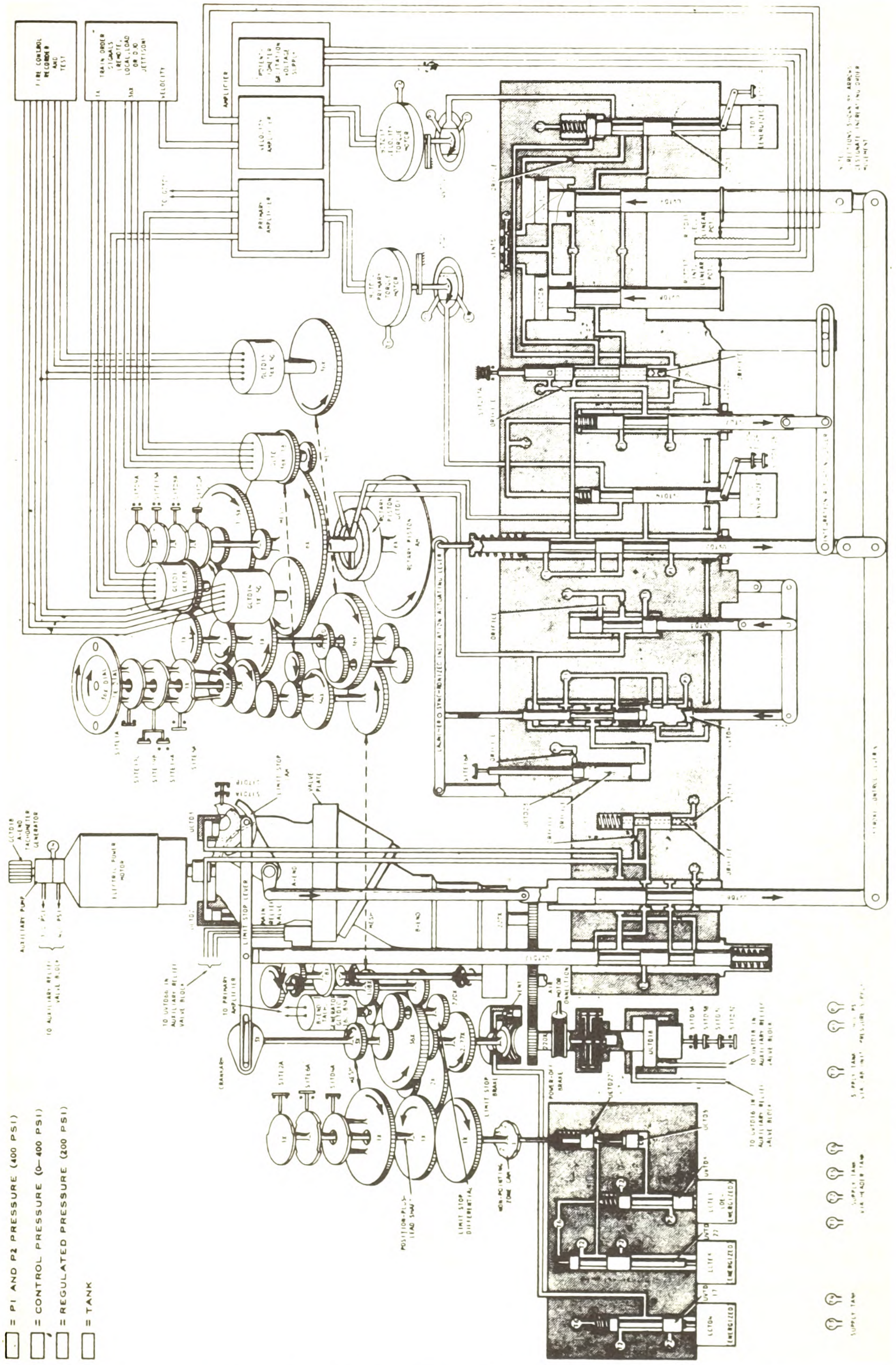
This topic is included to point out the differences in construction features, design techniques, and overall arrangements of other models of receiver regulators used in launchers and guns, compared to the receiver-regulator types described in Topics 1 through 7 of this section. Since it would be impossible in the space and time available to explain all the operations of individual components, only the major differences between various regulator models will be pointed out.

Illustration #14-61 on the following page shows the train receiver-regulator used on the early models of the launcher Mk 5 . Basically, the functions of this regulator are similar to those of the later models described in Topics 1 through 7, only several of the individual components are constructed differently. Note the following differences which can be found in the early models of receiver regulators:

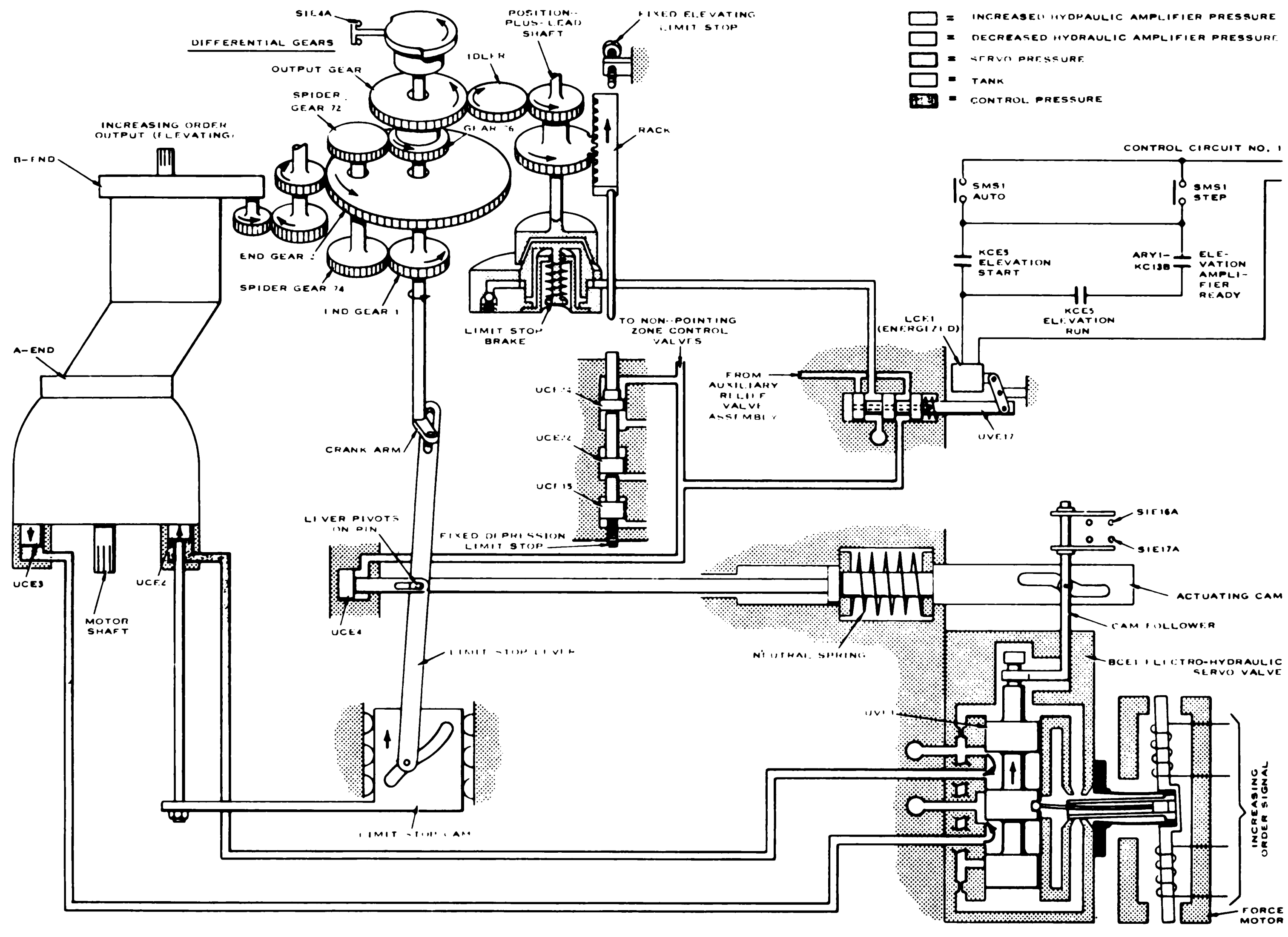
1. Torque motors and rotary valves are used instead of electro-hydraulic servo-valves, but the torque motors are controlled by conventional tube amplifiers instead of being controlled by magnetic amplifiers.

2. UVTD3 controls the fluid pressure to the response side of the rotary piston as in the later model, but the movement of UVTD3 is mechanically controlled by the sleeve of UVTD4.

3. The sleeve of UVTD4, instead of the sleeve of UVTD3, controls neutralization of the integration system.



14-61. TRAIN RECEIVER-REGULATOR USED ON THE EARLY MODELS OF LAUNCHER MK 5 (SCHEMATIC)



14-62. NEW DESIGN LAUNCHER RECEIVER-REGULATOR (SCHEMATIC)

All launcher receiver-regulators were similar to the two types discussed in the preceding topics, until launcher Mk 116, used with missile launching system Mk 13, was designed. The newly designed launcher uses an amplifier (electronic servo control-unit) which electrically performs many of the functions that were previously performed hydraulically by other types of receiver-regulators. A brief description of the differences in this new receiver-regulator model compared with the older type receiver regulators follows:

1. A modified synchro system is used, with B-end response positioning the synchro rotors. There is no rotary piston response.

2. Only one modified electrohydraulic servo-valve is used. Both chambers of the electrohydraulic servo-valve plunger are utilized, and each chamber is directly connected to an A-end stroking piston. Both stroking pistons have areas equal in size for hydraulic pressure to act upon.

3. A-end response is transmitted electrically by a potentiometer to the amplifier and mechanically to the limit-stop and automatic tracking cutout systems.

4. A modified limit-stop system is used to mechanically return the electrohydraulic servo-valve and thus the A-end to neutral.

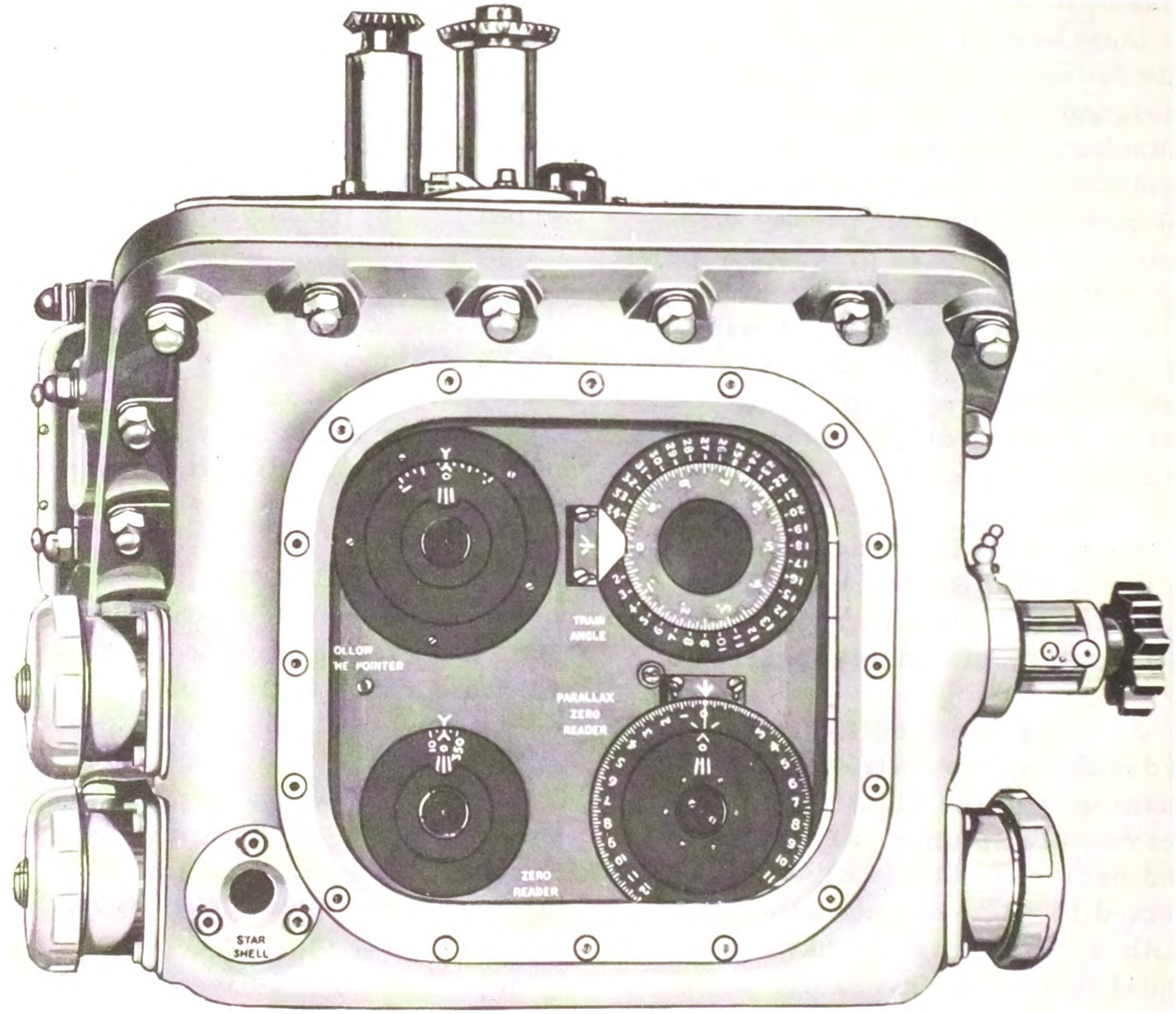
5. The automatic tracking cutout system is similar to the one used in the launcher Mk 5. This system utilizes the limit-stop system to stop the power drive.

6. There are no hydraulic velocity and integration systems in the regulator; however, a velocity signal is electrically applied to the amplifier.

Illustration #14-62 is a schematic of a new design elevation receiver-regulator and CAB unit (less synchro assembly and less part of the automatic tracking system).

The 5"38-cal. twin gun-mounts use indicator receiver-regulators (indicator regulators) to control the train and elevation power drives. These regulators perform the same basic functions of hydraulically controlling the train and elevation power drive A-ends as the receiver-regulators discussed in Topics 1 through 7; however, their physical arrangement, operations, and control methods are quite different from those used on missile launchers.

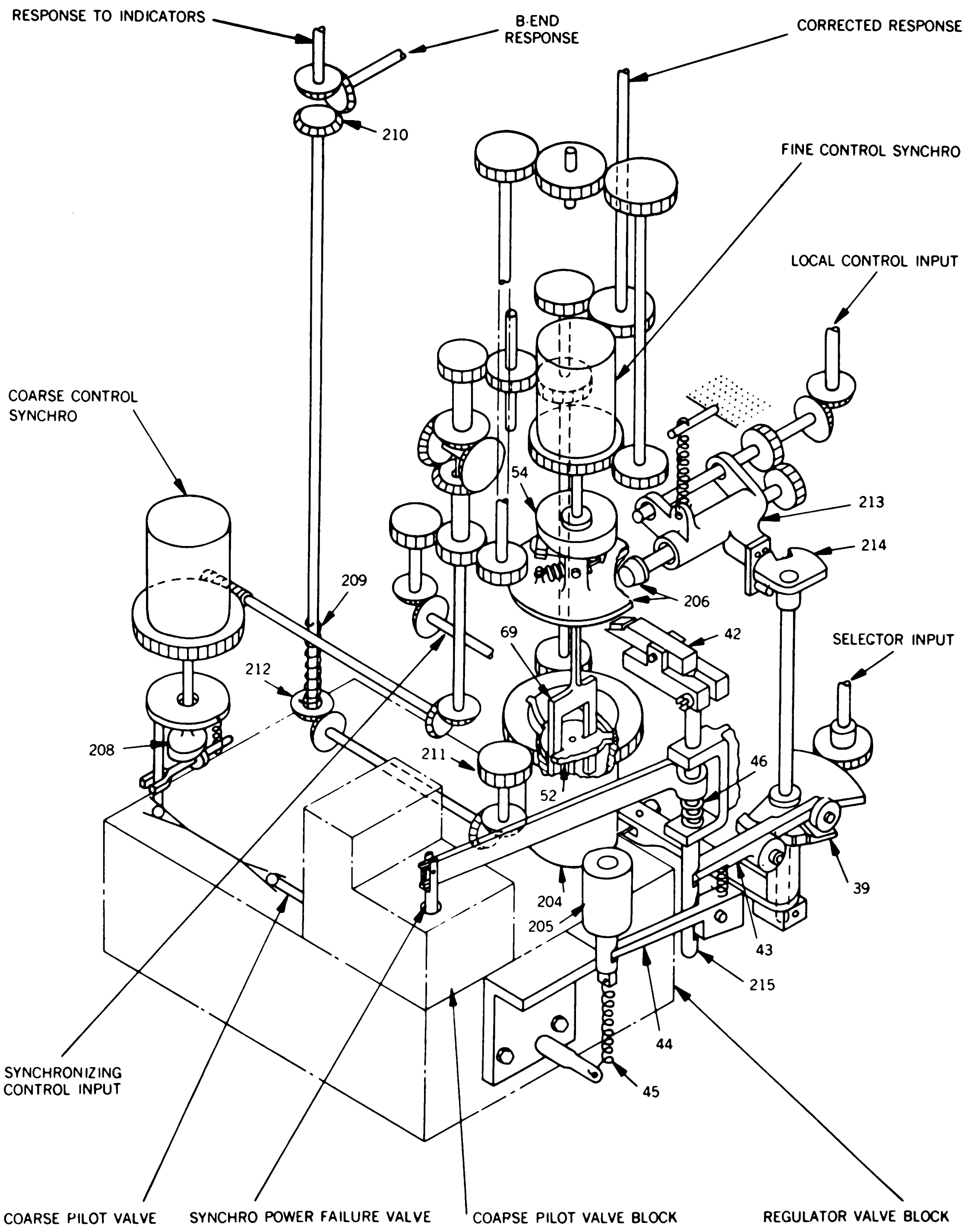
Illustration #14-63 on the following page shows the top view of the indicator section of the train indicator-regulator. The indicator section is included in the regulator to enable the train operator to instantly determine the mount-position in train, the parallax input, and the direction in which the mount must train, to follow the order signal from the director.



14-63. TRAIN INDICATOR-REGULATOR MK 46

The external parallax, zero-reader, and follow-the-pointer inputs are all transmitted to the indicator regulator by a torque synchro system.

The receiver regulator can be controlled either by a torque synchro system (automatic control) or can be controlled mechanically (local control). In a torque synchro system, the pilot valves that originate the hydraulic signal to control the A-end are mechanically positioned by torque synchro-receiver (TR) rotors. (The fine, 36-speed, control synchro and coarse, 1-speed, control synchro are shown



14-64. ELEVATION AND TRAIN INDICATOR-REGULATORS MK 42 AND MK 46, RECEIVER ASSEMBLY (SCHEMATIC) in illustration #14-64 on the preceding page; note that B-end response mechanically positions the TR-stators.)

The local control mechanical input to the regulator (also shown in illustration #14-64) is used when the regulator is to be controlled by handwheels (local control). A selector lever is shifted to mechanically perform the following functions:

1. To allow the mechanical handwheel input to engage a cam and take control away from the fine synchro (note 214, 213, and 206 in illustration #14-64).

2. To position a selector valve in the valve-block; this valve blocks the hydraulic input from the coarse pilot valve.

A listing of other basic differences of the 5"38 twin-mount indicator-regulator compared to the launcher receiver-regulator follows:

1. A horizontal parallax assembly is included in the train power drive to compensate for the horizontal base length between the gun and director.

2. A roller-path compensator is included in the elevation regulator to correct the operation of the elevation power drive by compensating for any inclination of the mount roller-path with respect to the reference plane of the director.

3. Two pressures (one variable and one constant) are used to control the A-ends of the train and elevation power-drives. These power-drives, however, use only one stroke piston each. The use of only one stroke piston is made possible due to the area differential at each end of the stroke piston.

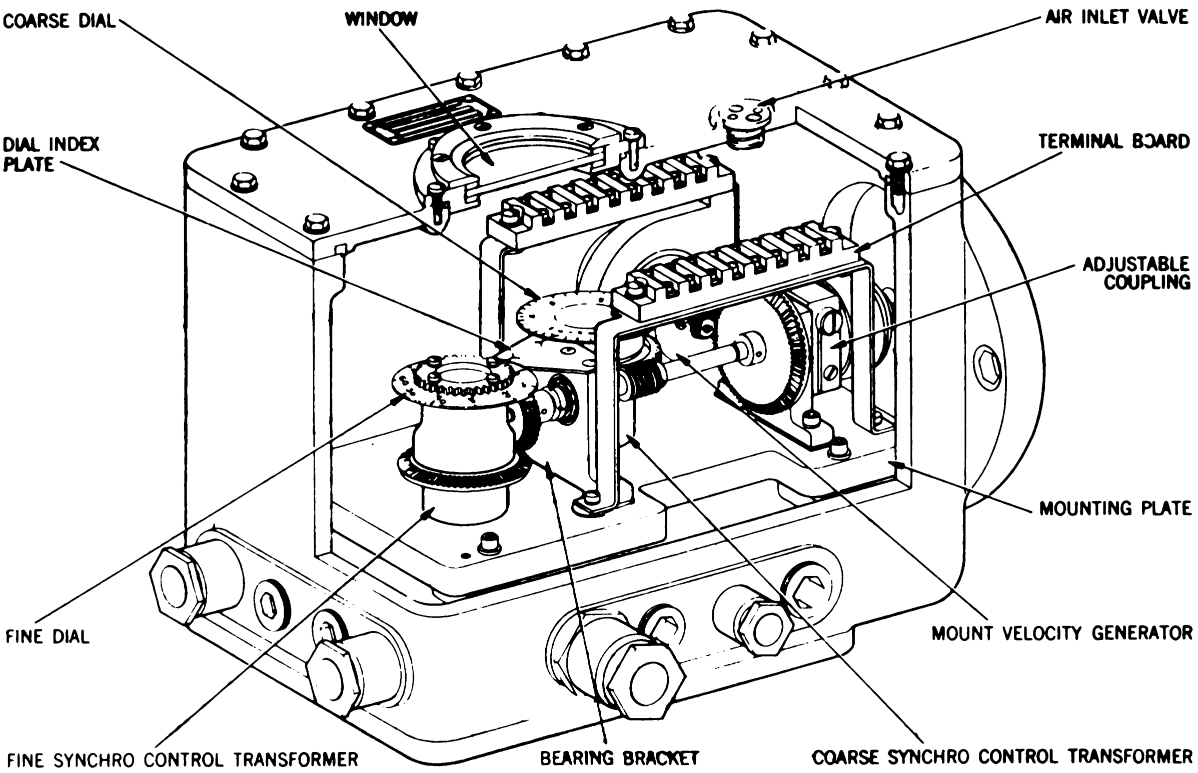
4. A hydraulic synchronizing control device (SCD) is used to allow the power drive to synchronize with a director without overtravel.

5. A synchro power-failure device is used in the indicator regulator to stop the power drive whenever a power failure occurs.

The rocket launcher Mk 108 does not use a receiver-regulator; however, a device called the B-end synchro-unit and the stroke control-unit in the power drive perform the functions of a receiver-regulator.

The train B-end synchro unit for the rocket launcher Mk 108 is shown in illustration #14-65 on the following page. This unit consists of a 1-speed and 36-speed CT and a mount velocity-generator. B-end response is transmitted through the adjustable coupling (shown in illustration #14-65) to position the CT rotors dials, and the mount velocity-generator. The error signal is generated on the CT rotor windings and is transmitted to the amplifier. The dials in the synchro unit indicate launcher train position.

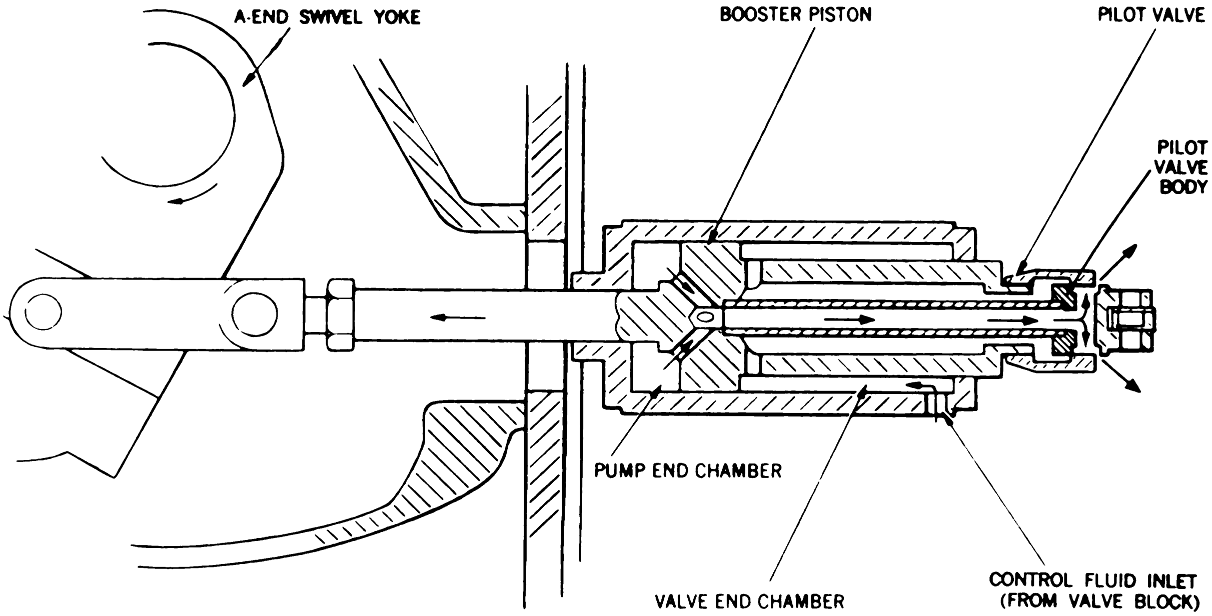
The mount velocity-generator



14-65. TRAIN SYNCHRO UNIT, INTERNAL ARRANGEMENT

transmits a voltage, which is proportional to the train speed, to the amplifier. The mount velocity is compared in the amplifier with the director velocity and the result is used to increase the accuracy of the power drive.

The train A-end is controlled by a stroke control assembly located on the power-drive. The amplified error signal is used to drive a variable speed induction (stroke) motor. Gearing and linkage from the induction motor positions a pilot valve which hydraulically controls a booster piston. The booster-piston movement is transmitted by a yoke and link to the train A-end. (Il-



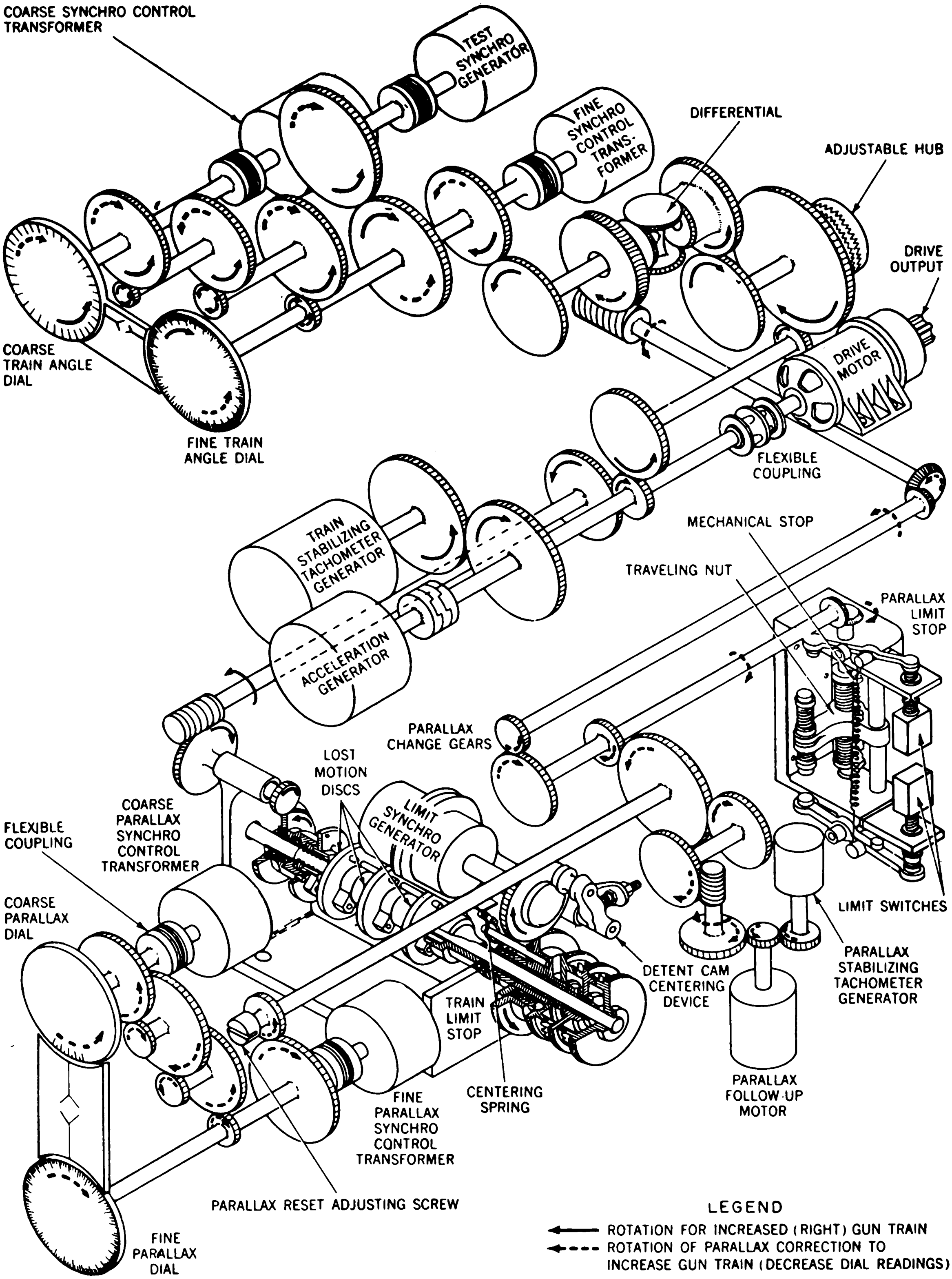
14-66. BOOSTER CYLINDER OPERATION, PISTON MOVING TOWARD A-END PUMP

lustration #14-66 shows the general arrangement of the pilot valve, booster piston, and A-end.)

The receiver regulator for the 3"50-caliber RF-mount train power-drive (shown in illustration #14-67 on the following page) includes a 1-speed and 36-speed CT, a train limit-stop mechanism, a parallax corrector mechanism, train position dials, a train stabilizing tachometer generator, and an acceleration generator. This receiver-regulator (unlike the missile-launcher and 5"38-regulators) originates only the error signal. The error signal, after being transmitted from the receiver-regulator to the amplifier, is used to control the electrical output of an amplidyne generator. The output of the amplidyne generator is used to control the DC train drive-motor located on the gun mount.

Both the remote order and local order signals are applied to the stator fields of the 1-speed and 36-speed CT's. Mechanical response from the DC train drive-motor positions the rotors of the CT's to cancel the error signal when the mount is synchronized with the director. Response from the train drive-motor also positions the limit-stop mechanism, the train angle dials, and drives the acceleration generator and stabilizing tachometer generators.

A brief description of some other special features of the 3"50-cal. RF gun-mount receiver-regulator compared to other type receiver regulators follows.


COARSE SYNCHRO CONTROL TRANSFORMER
TEST SYNCHRO GENERATOR
FINE SYNCHRO CONTROL TRANS-FORMER
DIFFERENTIAL
ADJUSTABLE HUB
DRIVE OUTPUT
DRIVE MOTOR
COARSE TRAIN ANGLE DIAL
FINE TRAIN ANGLE DIAL
FLEXIBLE COUPLING
MECHANICAL STOP
TRAIN STABILIZING TACHOMETER GENERATOR
TRAVELING NUT
PARALLAX LIMIT STOP
ACCELERATION GENERATOR
PARALLAX CHANGE GEARS
LOST MOTION DISCS
LIMIT SYNCHRO GENERATOR
COARSE PARALLAX SYNCHRO CONTROL TRANSFORMER
FLEXIBLE COUPLING
COARSE PARALLAX DIAL
LIMIT SWITCHES
PARALLAX STABILIZING TACHOMETER GENERATOR
DETENT CAM CENTERING DEVICE
TRAIN LIMIT STOP
CENTERING SPRING
FINE PARALLAX SYNCHRO CONTROL TRANSFORMER
PARALLAX FOLLOW-UP MOTOR
PARALLAX RESET ADJUSTING SCREW
FINE PARALLAX DIAL
LEGEND
ROTATION FOR INCREASED (RIGHT) GUN TRAIN
ROTATION OF PARALLAX CORRECTION TO INCREASE GUN TRAIN (DECREASE DIAL READINGS)

14-67. TRAIN RECEIVER-REGULATOR MK 29 MOD 0, MECHANICAL ARRANGEMENT (SCHEMATIC)

1. The limit-stop mechanism stops the train power-drive by transmitting to the amplifier a synchro signal which cancels the error signal.

2. Parallax is applied to the power drive by offsetting the 1-speed and 36-speed rotors by means of a differential.

QUIZ SHEETS:

1. The launcher power-drive B-end response to the receiver regulator is of the following type:

   a. Electric.
   b. Electronic.
   c. Mechanical.
   d. Hydraulic.

2. BCTD1 converts the electrical velocity signal to a hydraulic signal.

   True ______ or False ______.

3. Launcher B-end response positions the stator of GCTD11 in the receiver-regulator Mk 45.

   True ______ or False ______.

4. The train receiver-regulator Mk 45 nonpointing-zone cam is positioned by

   a. B-end response.
   b. A-end response.
   c. A-end and B-end responses.
   d. Rotary piston.

5. When the receiver-regulator Mk 45 is operated in primary control only, the rotary piston must remain displaced, to keep the A-end on tilt.

   True ______ or False ______.

6. In normal automatic operation, the launcher and director are synchronized and are training to the right at 10° per second. If these conditions exist, are BCTD1 and BCTD2 approximately on neutral or off neutral to the right?

   a. BCTD1 ______________.
   b. BCTD2 ______________.

7. When the lower chamber (as shown schematically) of UVTD20 is connected to tank, the integration control pressure from the center chamber of UVTD7 is

   a. Blocked.
   b. Undisturbed.
   c. Connected to tank.
   d. Connected to UCTD8.

8. RATD2 develops the integration response signal for the velocity amplifier.

   True ______ or False ______.

9. When the launcher is 3° from synchronizing with a director that is moving 10° per second, which of the valves prevents the integration system from activating?

   a. UVTD2.
   b. UVTD3.
   c. UVTD4.
   d. UVTD10.

10. Which valve develops the hydraulic pressure required to to return the velocity piston UCTD7 to neutral when LCTD3 deenergizes?

    a. UVTD20.
    b. UVTD10.
    c. UVTD9.
    d. UVTD8.

11. The train limit-stop system and automatic tracking cutout system both utilize UVTD12 to stop the launcher.

    True ______ or False ______.

12. On the elevation receiver regulators serial #10 and above (described in Topics 1 through 7), a crank arm is utilized to transmit the limit-stop lever-movement to the limit-stop differential.

    True ______ or False ______.

13. In the receiver-regulators used with the early-model launchers Mk 5, UVTD3 is

    a. Hydraulically balanced.
    b. Omitted.
    c. Used to cut out the integration system.
    d. Mechanically controlled by the sleeve of UVTD4.

14. Only one electrohydraulic servo-valve is used on the launcher receiver-regulators associated with the missile launching system Mk 13.

    True ______ or False ______.

15. The synchros that originate the error signal in the 5"38-caliber twin gun-mount indicator receiver-regulators are classified as

    a. CT's.
    b. CTB's.
    c. TR's.
    d. TX's.

16. The local control input to the 5"38-caliber twin gun-mount indicator receiver-regulator is applied electrically.

    True ______ or False ______.

17. A horizontal parallax assembly is included in the 5"38-caliber twin gun-mount indicator receiver-regulator to compensate for one of the following:

    a. Roller-path tilt.
    b. Horizontal base-length between the gun and director.
    c. Inherent lag.
    d. Static friction.

18. Name the two units in the rocket launcher Mk 108 which perform the functions of a receiver-regulator.

a. ______________________.
b. ______________________.

19. The 3"50-caliber RF gun-mount receiver-regulator converts the electric error signal into a hydraulic signal.

True ______ or False ______.

20. The limit-stop mechanism in the 3"50-caliber RF gun-mount receiver-regulator stops the gun mount by transmitting a

a. Hydraulic signal.
b. Mechanical signal.
c. Hydraulic and mechanical signal.
d. Synchro signal.

Accuracy of notes checked by instructor:

Date ______________________________

Trainee's initials ___________________

Section 15

EXPLOSIVE ORDNANCE

ASSIGNMENT-DISCUSSION-QUIZ SHEETS

Topic No.	Topic Title	Page
1.	Development of Navy Ammunition	340
2.	Explosive Materials	342
3.	Gun Ammunition	344
4.	Projectiles	346
5.	Fuzes and Tracers	348
6.	Pyrotechnics	350
7.	Bomb-Type Ammunition and Demolition Equipment	352
8.	Rockets and Solid Fuel Rocket Motors	354
9.	Tests and Inspections	356
10.	Handling Techniques and Safety Precautions	358

TOPIC 1: DEVELOPMENT OF NAVY AMMUNITION

You Are Now Going To Learn:

1. The origin of gun powder (general information).
2. The explosive reactions.
3. The classification of explosives.
4. Review and summary.

Discussion Points For This Topic Are:

1. Origin of explosives.
2. General information about explosives.
3. Classification of explosives according to service use:
   a. Propellants.
   b. Initiating explosives.
   c. Burster high explosives.
   d. Auxiliary explosives.

ASSIGNMENT:

A. Reference publications:

   1. Study OP 4, Volume 1, Chapter 1.

   2. Optional reading list:

      a. NavPers 16194, Chapter 1.

INFORMATION AND DISCUSSION:

The discussion points listed in this topic are thoroughly covered in the assignment.

TOPIC 2: EXPLOSIVE MATERIALS

You Are Now Going To Learn:

1. The types, characteristics, and uses of explosives.

Discussion Points For This Topic Are:

1. Types, characteristics, and uses of black powder.
2. Types, characteristics, and uses of smokeless powder.
3. Types, characteristics, and uses of high explosives:
   - a. TNT.
   - b. Ammonium picrate (explosive D).
   - c. Tetryl.
   - d. Tetrytol.
   - e. RDX.
   - f. HBX.
4. Review and summary.

ASSIGNMENT:

A. Reference publications:

1. Study OP 4, Volume 1, Chapters 2, 3, and 4.
2. Optional reading list:
   - a. NavPers 16194, Chapter 1.

INFORMATION AND DISCUSSION:

The discussion points listed in this topic are thoroughly covered in the assignment.

TOPIC 3: GUN AMMUNITION

You Are Now Going To Learn:

1. The classification and types of naval gun ammunition.

2. The classification and purpose of primers.

3. The characteristics of propellants.

Discussion Points For This Topic Are:

1. Classification of gun ammunition.

2. Types of gun ammunition:

   a. Fixed.
   b. Semifixed.
   c. Bag.
   d. Special.

3. Purpose of primers.

4. Types of primers:

   a. Case percussion.
   b. Case electric.
   c. Case combination.
   d. Lock combination.
   e. Drill.

5. Purpose of propellent charges.

6. Characteristics of propellants.

7. Review and summary.

ASSIGNMENT:

A. Reference publications:

   1. Study OP 4, Volume 1, Chapters 5, 6, and 7.

   2. Optional reading list:

      a. OP 2215.
      b. NavPers 16194, Chapter 2.

INFORMATION AND DISCUSSION:

The discussion points listed in this topic are thoroughly covered in the assignment.

TOPIC 4: PROJECTILES

You Are Now Going To Learn:

1. The types, design characteristics, and components of projectiles.

2. The identification of projectiles.

Discussion Points For This Topic Are:

1. Design characteristics and functions of the following projectile components:

   a. Ogive.
   b. Cap.
   c. False ogive or windshield.
   d. Base.
   e. Body.
   f. Bourrelet band.
   g. Explosive cavity.

2. Characteristics and construction features of the following types of projectiles:

   a. Armor-piercing.
   b. Fragmenting.
   c. Special purpose.
   d. Other type.

3. Color code used for projectile identification.

4. Review and summary.

ASSIGNMENT:

A. Reference publications:

   1. Study OP 4, Volume 1, Chapter 9, and NavPers 16194, Chapter 2, pages 31 through 33.

   2. Optional reading list:

      a. OP 2215.

INFORMATION AND DISCUSSION:

The discussion points listed in this topic are thoroughly covered in the assignment.

TOPIC 5: FUZES AND TRACERS

You Are Now Going To Learn:

1. The classification and operational principles of fuzes used by the Navy.
2. The purpose and types of tracers.

Discussion Points For This Topic Are:

1. Types and functions of fuzes.
2. Operational principles of the following types of projectile fuzes:
   a. Point-detonating.
   b. Base-detonating.
   c. Mechanical time.
   d. Auxiliary detonating.
   e. Proximity.
3. Types and operations of bomb fuzes.
4. Types and operations of rocket fuzes.
5. General information about various types of missile fuzes.
6. Purpose and types of tracers.
7. Review and summary.

ASSIGNMENT:

A. Reference publications:

1. Study OP 4, Volume 1, Chapter 8.
2. NavPers 10784, Chapter 3, pages 41 through 43.
3. NavPers 16194, Chapter 2, pages 35 through 48.
4. OP 2215.

INFORMATION AND DISCUSSION:

The discussion points listed in this topic are thoroughly covered in the assignment.

TOPIC 6: PYROTECHNICS

You Are Now Going To Learn:

1. The definitions, types, and uses of pyrotechnics.

Discussion Points For This Topic Are:

1. Definition of pyrotechnics.
2. Types and functions of surface pyrotechnics.
3. Types and functions of aircraft pyrotechnics.
4. Hazards of pyrotechnics.
5. Handling and stowage of pyrotechnics.
6. Review and summary.

ASSIGNMENT:

A. Reference publications:

1. Study OP 4, Volume 1, Chapter 17, and NavPers 16194, Chapter 5, pages 75 and 76.
2. Optional reading list:
    a. OP 2213.

INFORMATION AND DISCUSSION:

The discussion points listed in this topic are thoroughly covered in the assignment.

TOPIC 7: BOMB-TYPE AMMUNITION AND DEMOLITION EQUIPMENT

You Are Now Going To Learn:

1. The characteristics of various types of aircraft bombs.
2. The types of depth charges and their firing mechanisms.
3. The types of missile warheads.
4. The types and uses of demolition charges and demolition equipment.

Discussion Points For This Topic Are:

1. Types, construction features, and uses of bombs and their fillers.
2. Types and characteristics of depth charges.
3. Depth charge firing mechanisms.
4. General information about various types of missile warheads.
5. Functions of demolition materials.
6. Types and uses of demolition devices and charges.
7. Accessories used with demolition charges and items contained in demolition outfits.
8. Review and summary.

ASSIGNMENT:

A. Reference publications:

   1. Study OP 4, Volume 1, Chapters 13, 16, and 19, pages 19.8 through 19.12.
   2. Study NavPers 10784, Chapter 3, pages 38 through 41.
   3. Optional reading list:
      a. NavPers 16194, Chapter 4.
      b. NavWeps OP 2212.

INFORMATION AND DISCUSSION:

The discussion points listed in this topic are thoroughly covered in the assignment.

TOPIC 8: ROCKETS AND SOLID FUEL ROCKET MOTORS

You Are Now Going To Learn:

1. The theory of rocket propulsion.
2. The construction features of rockets and rocket motors.
3. The characteristics of solid-fuel rocket motors used for missiles.

Discussion Points For This Topic Are:

1. Theory of rocket propulsion.
2. Stabilization of rockets in flight.
3. Classification of rockets by various uses.
4. Types and construction features of rocket heads.
5. Types and construction features of rocket motors.
6. Review and summary.

ASSIGNMENT:

A. Reference publications:
   1. Study OP 4, Volume 1, Chapters 12 and 19, pages 19.2 through 19.4.
   2. Study NavPers 16194, Chapter 6, pages 105 through 117.

INFORMATION AND DISCUSSION:

The discussion points listed in this topic are thoroughly covered in the assignment.

TOPIC 9: TESTS AND INSPECTIONS

You Are Now Going To Learn:

1. The procedures of visual observation, inspection, and examination of ammunition onboard naval vessels.
2. The purpose of and procedures for conducting the 65.5° C. surveillance test of smokeless powder.

Discussion Points For This Topic Are:

1. Purpose of daily inspection of magazines.
2. Methyl-violet paper test:
    a. Principles of test.
    b. Types of paper used.
    c. Objects of test.
    d. Methods of conducting test.
    e. Reports.
3. Monthly examination of replacement samples and smokeless powder charges.
4. Surveillance of other types of ammunition.
5. 65.5° C. surveillance test of smokeless powder:
    a. Frequency of tests.
    b. Principles of tests.
    c. Test equipment.
    d. Methods of conducting tests.
    e. Reports and action required.
6. Review and summary.

ASSIGNMENT:

A. Reference publication:
    1. Study OP 4, Volume 2, Chapters 5 and 6.

INFORMATION AND DISCUSSION:

The discussion points listed in this topic are thoroughly covered in the assignment.

TOPIC 10: HANDLING TECHNIQUES AND SAFETY PRECAUTIONS

You Are Now Going To Learn:

1. The regulations and safety precautions for handling ammunition.
2. The regulations for stowage of ammunition.
3. The use of special equipment for handling ammunition.
4. The hazards prevalent in conventional explosives used in nuclear weapons.

Discussion Points For This Topic Are:

1. General requirements and safety precautions for handling ammunition.
2. Personnel and supervisor requirements.
3. Handling instructions for specific types of ammunition.
4. Use of ammunition handling equipment and special techniques for handling ammunition.
5. Ammunition stowage requirements.
6. Hazards prevalent in conventional explosives used in nuclear weapons.
7. Review and summary.
8. Section review.
9. Written test.

ASSIGNMENT:

A. Reference publications:

   1. Study OP 4, Volume 2, Chapters 2, 4, and 10.
   2. Study NavPers 16194, Chapters 8 and 10.

INFORMATION AND DISCUSSION:

Requirements and precautions relating to nonnuclear ammunition are adequately covered in the above reading assignment.

Since nuclear weapons contain conventional explosive materials in lethal quantities, all of the techniques and safety precautions for thin-cased bomb-type ammunition must be considered applicable to handling of nuclear weapons.

Nuclear weapons also contain radioactive materials and may contain chemically poisonous materials; under normal circumstances and when handled according to specified procedures, these materials offer no personnel hazards. To ensure against such hazards and to ensure reliability, nuclear weapons are handled only by trained and authorized personnel who know and follow authorized procedures.

Under abnormal circumstances, for example, when a weapon is dropped, mechanically damaged, enveloped in flames, or involved in an explosion, special hazards may exist. Some of the unpleasant possibilities follow:

1. Explosion or burning of high explosives.
2. Scattering of pieces of high explosive as a result of breakup of the weapon.
3. Spread of radioactive materials and/or chemical poisons (in the form of particles or fumes) due to explosion, breakup, or burning of the weapon.
4. Increased radioactivity levels in the vicinity of the weapon proper.

These hazards suggest that the following common-sense rules be observed by personnel who may be casually associated with nuclear weapons but who are not trained and authorized to handle them.

1. Under normal circumstances: leave the weapon alone.
2. In case of an accident or fire:
    - a. Give the alarm and offer your assistance.
    - b. If there are qualified personnel on hand to handle the situation without your assistance, get out of the way promptly; spectators are not required!
    - c. In any case, stay out of the smoke from a fire which involves a nuclear weapon.

QUIZ SHEETS:

1. High speed develops maximum pressure in an explosive and produces a shattering effect which is called

   a. Velocity.
   b. Pressure.
   c. Brisance.
   d. Reaction.

2. A high explosive is a substance which can be easily detonated by a blow or shock.

   True _______ or False _______.

3. Which of the following is not a high explosive?

   a. Smokeless powder.
   b. HBX.
   c. TNT.
   d. Ammonium picrate.

4. Mercury fulminate is classified as an initiating explosive.

   True _______ or False _______.

5. An explosive mixture is a homogeneous substance whose molecules contain the oxygen, carbon, and hydrogen required for either a partial or complete combustion.

   True _______ or False _______.

6. The 5"38-caliber guns are classified as

   a. Small arms.
   b. Minor caliber guns.
   c. Medium caliber guns.
   d. Major caliber guns.

7. The barrel length of a 5"38-caliber gun is _______ inches.

8. Gun ammunition with separate projectiles, primers, and propellants located in plugged cartridge cases is classified as

   a. Semifixed.
   b. Fixed.
   c. Bag.
   d. Special.

9. Saluting cartridges are loaded with

   a. Smokeless powder.
   b. Black powder.
   c. HBX.
   d. RBX.

10. A lock combination primer is used with bag ammunition.

    True _______ or False _______.

11. The forward bearing surface of a projectile is called

    a. Bourrelet.
    b. Rotating band.
    c. Ogive.
    d. Body.

12. The projectile used to scatter metal foil in the air is called

    a. Common.
    b. Illuminating.
    c. High-capacity.
    d. Window.

13. Projectiles which possess anti-aircraft characteristics and the toughness required to penetrate steel plating are called ________ ____________________ projectiles.

14. Indicate the colors of a common projectile loaded with explosive D.

    a. Body color: ____________.
    b. Nose color: ____________.

15. Black powder is very sensitive to friction and shock, sparks and flame.

    True ______ or False ______.

16. The principal constituent of smokeless powder is

    a. Diphenylamine.
    b. Dinitrotoluene.
    c. Dibutylphthalate..
    d. Nitrocellulose.

17. Which type of smokeless powder contains nitroglycerin?

    a. SPD.
    b. SPDN.
    c. SPCG.
    d. SPDF.

18. Which type of smokeless powder is generally used for target practice?

    ____________________________.

19. The major part of high explosives is derived from coal-tar products.

    True ______ or False ______.

20. Which high explosive is used as a standard for comparing other high explosives?

    a. Nitroglycerin.
    b. TNT.
    c. Explosive D.
    d. RDX.

21. The most important high explosive recently developed is

    a. TNT.
    b. Explosive D.
    c. Tetryl.
    d. RDX.

22. The fuzes of most types of projectiles are armed by setback and ____________________.

23. Setback occurs when the projectile, after it is fired, strikes an object.

    True ______ or False ______.

HANDLING TECHNIQUES AND SAFETY PRECAUTIONS

24. The bomb-type mechanical time-fuze is primarily used in

a. Depth bombs.
b. Armor-piercing bombs.
c. Incendiary bombs.
d. Semiarmor-piercing bombs.

25. In spin-stabilized rockets, nose fuzes are armed by centrifugal force.

True ______ or False ______.

26. The color of a smoke hand-signal for day-distress is

a. White.
b. Black.
c. Red.
d. Orange.

27. The 7.2-inch projector-charge has a split tail-ring.

True ______ or False ______.

28. The propellant used in rocket motors is a double-base smokeless powder consisting of nitrocellulose and ________ ________________.

29. Armor-piercing bombs are thickwalled bombs filled with explosive D and equipped with nose fuzes.

True ______ or False ______.

30. The booster extender arms depth charges Mk 6 and Mk 9 by hydrostatically extending the booster to envelop the ______________________.

31. How often shall powder replacement samples be inspected?

a. Daily.
b. Weekly.
c. Monthly.
d. Yearly.

32. The purpose of the methyl-violet paper test is to provide a continuous visual indication of

a. Powder stability.
b. Powder burning rate.
c. Powder age.
d. Powder appearance.

33. The 65.5° C. surveillance tests of all indexes of smokeless powder shall be started

a. Weekly.
b. Monthly.
c. Semiannually.
d. Annually.

34. The 65.5° C. surveillance tests of smokeless powder in crimped cartridges are conducted by

    a. The nearest ammunition activitv.
    b. Each ship.
    c. Tenders.
    d. Navy yards.

35. Pyrotechnics shall never be stowed together with other types of ammunition.

    True ______ or False ______.

Accuracy of notes checked by instructor:

Date ________________________________

Trainee's initials ____________________

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